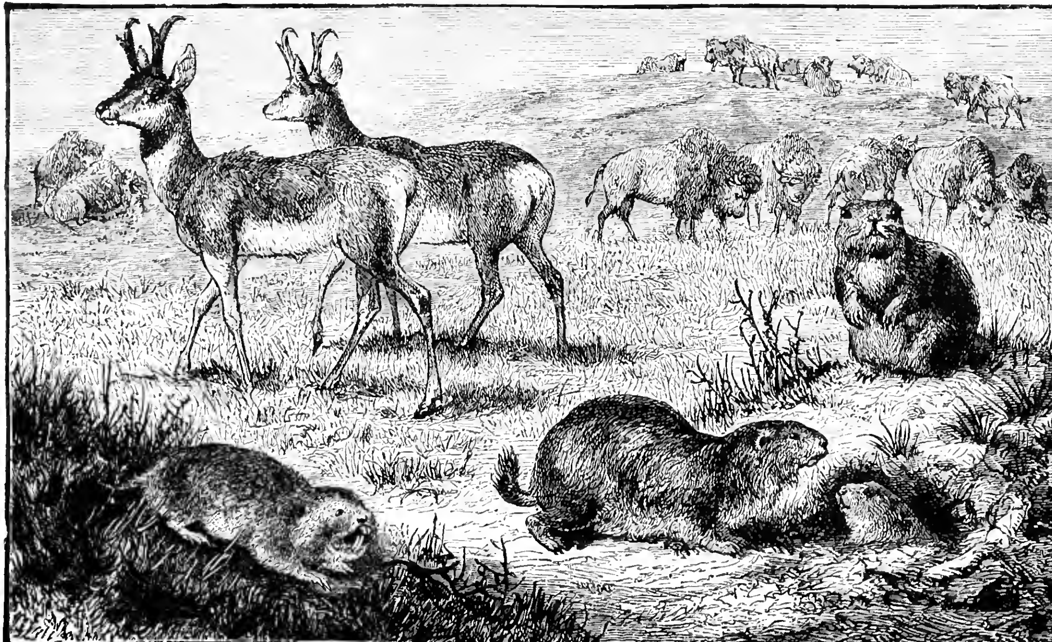

CHARACTERISTIC MAMMALIA OF THE AMERICAN PRAIRIES.—*After Wallace.*

AMERICAN SCIENCE SERIES, BRIEFER COURSE

ZOOLOGY

BY

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SIXTH EDITION, REVISED

NEW YORK
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PREFACE.

THIS brief compendium of Zoology is designed for use in grammar and high schools. It is introductory to the author's larger Zoology. Though partly rewritten, and with additions regarding the habits of birds and mammals, portions of the larger book have been retained, the more difficult parts being omitted so as to adapt it for younger pupils, or those whose time is limited.

No class in the study of Zoology should depend on a book alone, but specimens should be in constant use,—the text-book being rather for reference,—as all school work in Zoology should be object-teaching. Before taking up the book, each member of the class should be required to examine a fish—a perch, cunner, smelt, or any common fish; the pupil should then draw it with all the fins expanded; then with the aid of the directions on pages 154 to 157, by means of a small scalpel, forceps, and scissors, the student should dissect the fish, drawing the heart, stomach, etc., and a transverse section; a preparation of the brain can be easily made with the aid of a competent teacher. Having thus obtained some notion of the structure of a common vertebrate animal as a basis of comparison, the class can begin to study the book: meanwhile once or twice a week, if not oftener, taking a laboratory lesson, drawing and dissecting a star-fish, clam, or fresh-water mussel; a lobster or crayfish; a horseshoe crab, locust or grasshopper; and finally a fish, frog, and cat. A small collection of corals, shells, and a few typical dried or alcoholic insects, and skeletons of a fish, frog, reptile, bird, and cat, should also be examined and referred to constantly in using this or any other text-book. In this way, and with an occasional field excursion after living animals, the study of Zoology can be made of the highest interest and value, calling out both the observing and reflective faculties.

For collateral reading, the teacher or student is referred to the works of Huxley, Gegenbaur, Darwin, and Brooks' Invertebrate Zoology; for a work on shells, Woodward's Manual of Mollusca; on insects, Packard's Guide to the Study of Insects; on birds, Coues' Key to the Birds of North America; for a magazine of natural history, to the *American Naturalist*. A further list is given in the author's larger Zoology.

While most of the cuts are taken from the larger Zoology, where their source has been already acknowledged, a few are borrowed from Lütken's Zoology (in Danish); Brooks' Invertebrate Zoology; Emerton's Life on the Sea-Shore, published by S. E. Cassino; and Nordenskiöld's Voyage of the Vega, published by Macmillan & Co.; a few cuts of Crustacea are from Hayden's Twelfth Annual Report U. S. Geological Survey of the Territories, and Fig. 137 is from the Second Report of the U. S. Entomological Commission: these and others thus copied are duly acknowledged under each cut. A few of the illustrations are new.

PROVIDENCE, *Sept.* 25, 1883

Preface to the Second Edition.

The most important discovery made since this book was published is that the two lowest mammals, *i.e.*, the duck-bill and Echidna, both lay eggs which are introduced into the mammary pouch, where the young are hatched in a very rudimentary condition; the eggs have a soft parchment-like shell, and in the case of the spiny ant-eater, or Echidna, are nearly an inch (1½–2½ cm.) in length. References to these points are incorporated in the text. Moreover, the nervous system of Echinoderms has been found to consist of a delicate sheet lying under the soft integument, the thickenings seen by the naked eye forming the nervous ring and radial branches heretofore regarded as forming the nervous system of these animals. These and a few other corrections have been made in the present edition.

PROVIDENCE, *March*, 1885.

Preface to the Third Edition.

Recent discoveries, now generally accepted, have rendered necessary the following important changes in this work: The Tunicates are placed in the same sub-kingdom (*Chordata*) as the Vertebrates; the Merostomata and Trilobites are regarded as together forming a class of Arthropoda called *Podostomata*; the sub-kingdom Arthropoda is subdivided into six classes; the Malacopoda, Myriopoda, Arachnida, and Insecta being regarded as classes, instead of sub-classes, as in the former edition. The orders of insects have been increased from eight to sixteen. Numerous minor corrections have also been made.

PROVIDENCE, *June*, 1886.

PREFACE TO THE SIXTH EDITION.

Besides some verbal and a few other corrections and additions, no radical changes have been made in this edition, except the addition of lists of the most important works and essays, both on the general subject and on the different branches and some of the more important classes.

Recent studies show that the Echinoderms have originated from some primitive worm in which there was a body-cavity and a vascular system. The worm-like, footless Holothurians such as Synapta, and other Apoda, were the first to be evolved, and from these may have developed the normal Holothurians, which were succeeded by the Echinoids, the starfish, and perhaps finally the Crinoids, whose radiate shape was due to their fixed mode of life. If these views should prove correct the branch of Echinodermata should be placed between the Vermes and Mollusca, and the succession of orders given on pp. 41–46 should be reversed.

The researches of Claus, and the close resemblance between the legs of Phyllopods and the swimming appendages of certain Annelid worms, tend to show that the Crustacea originated from an Annelid-like worm and that the Phyllopods are perhaps the most generalized Crustacea. Hence on pages 86 to 94 the sequence of the first three orders of Crustacea should be as in the synoptical table on p. 85.

PROVIDENCE, *January*, 1892.

CONTENTS.

ZOOLOGY.

INTRODUCTION.

Definition of Zoology.—The study of nature comprises the examination both of minerals and of living beings, *i.e.*, plants and animals. Every natural object in this world which is lifeless belongs to the mineral kingdom: such are rocks, soils, water, air, and gas. Since plants and animals live and grow and have organs, or distinct parts which perform acts called functions, as the eye which sees, the hand which grasps, etc., all living beings are said to be *organic*, and all mineral bodies are said to be *inorganic*. It is customary to speak of the Mineral Kingdom, the Vegetable Kingdom, and the Animal Kingdom; but it is better to speak of the inorganic and the organic worlds, since all living beings or *organisms* have much in common which distinguishes them from mineral substances.

The study of plants is called *Botany*, and the study of animals *Zoology;* while the study of living beings in general, whether plants or animals, is termed *Biology*, which means the science of living beings.

Method of Study.—We study an animal, if it be a dog, for example, by observing its form, noticing its head, trunk, its four legs, etc. After a long and patient examination of the outer body we dissect it, examining the heart, stomach, brain and nerves, etc., and the skeleton. After a thorough study of a single specimen we should then compare it with a cat, and thus make our studies comparative. After such an examination we shall obtain a fair idea of the form and structure of the great class of mammalia, or mammals, of which the dog and cat are examples. Moreover, we should study how the animal walks, how its heart beats, or its eyes see. This is studying the *physiology* of the animal. Then we should learn how the animal grows or develops from the egg, and this is called *Embryology*, the germ of an animal being called an embryo. The bodies of animals are made up of *cells*. A cell is a microscopic portion consisting of a jelly-like substance called *protoplasm*. Animalcules are composed of but a single cell; such creatures are said to be *unicellular*, but most animals are formed of bone or shell, muscles, nerves, etc. These parts are made up of cells. Hence these animals are many-celled. The cells form *tissues*, such as muscular or nervous tissue. The study of cells and tissues is called *Histology*. Finally, we should acquaint ourselves with the habits and mental traits of the animal, and this is called *Psychology*.

A fish is the most convenient vertebrate for ordinary school laboratory work. The object of these lessons is to induce the scholar to depend as far as possible upon the use of his own eyes and brains. He should observe with care some of the common animals here described, most of which he can readily obtain, and then study their form, habits, and the leading features of their anatomy. After examining a starfish, clam, lobster, insect, and fish, and reading about their mode of growth, he will obtain a knowledge of the principal groups of the animal kingdom which he will remember throughout life.

Classification.—There are estimated to be upwards of 250,000 species of animals now living on the surface of the earth. How all these forms are related and how they differ comprises what is called the classification of animals or **Systematic Zoology.**

When Linnæus, the father of natural history, undertook to classify animals he divided the animal kingdom into classes, orders, genera, and species. Thus at present all animals, such as fishes, birds, or mammals, which have a backbone, are placed together in the branch or sub-kingdom of Vertebrates; those vertebrates, such as the cat, horse, or cow, which suckle their young, are placed in the class of Mammals; those mammals which have claws and teeth adapted for seizing and chewing flesh, *i.e.*, are carnivorous, belong to the order of *Carnivora*. The order of Carnivora is composed of a number of families, such as the cat family, the dog family, etc. A family is composed of a genus, and a genus is made up of species and varieties, the latter being composed of individuals.

Thus the principle of zoological classification consists in placing animals which are alike by themselves into distinct groups. The following table expresses the zoological position of the cat:

Kingdom of Animals;
  Sub-kingdom or *Branch*, Vertebrata;
    Class, Mammalia;
      Order, Carnivora;
        Family, Felidæ;
          Genus, Felis;
            Species, Felis domesticus;
              Variety, Angorensis;
                Individual, a single Angora cat.

The animal kingdom is divided into two series of branches: those for the most part composed of a single cell are represented by a single branch, the *Protozoa* (animalcules). Those animals whose bodies are formed of many cells are called *Metazoa*.* The series of *Metazoa* comprises the seven higher branches—*i.e.*, the *Porifera*, *Cœlenterata*, *Echinodermata*, *Vermes*, *Mollusca*, *Arthropoda*, and *Vertebrata*. Their relationships may be expressed by the following

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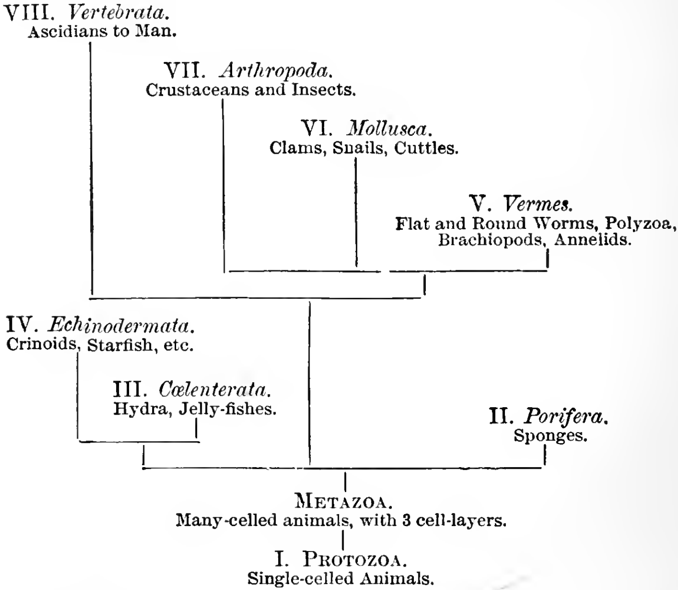
* In the latter group the cells are arranged in two, mostly three, fundamental cell-layers. Of these cell-layers the outermost is called the *ectoderm*, the middle the *mesoderm*, the innermost the *endoderm*.

TABULAR VIEW OF THE EIGHT BRANCHES OF THE ANIMAL KINGDOM



PALEONTOLOGY.—The existing animals were preceded in the earth's history by multitudes which are now extinct. Their remains in the shape of bones, teeth, or shells, etc., are called fossils, and the study of fossil animals and plants is called Paleontology.

GEOGRAPHICAL DISTRIBUTION.—Animals are not arbitrarily scattered over the earth's surface, but form assemblages of species which people any given spot or country. Such an assemblage of animals inhabiting a given place or area is called a *fauna*. Thus we may speak of the fauna of New York, or of the United States, or of North America. The animals of the arctic region belong to the arctic fauna; those of the tropics constitute the tropical fauna. We may also speak of the fauna of the land or of the ocean.

How to Begin the Study of Zoology.—In our rapid survey of the animal kingdom, in order to obtain a clear idea of what an animal is, and of the structure of some common, well-known type or example, we would earnestly advise the student to study some human physiology, such as Martin's "The Human Body," or any other at hand, and then to read the account of the anatomy of the fish in this book, and also study the skeleton and dissect a perch or any common fish. The student will thus have a standard of comparison, a standpoint from which to survey the animal world as a whole. He will thus learn the relations of the skeleton or solid framework of an animal to the muscles, etc., and learn what a heart, lung, or eye is. Then he can the better understand the structure of the lower animals.

This book begins with the lower, simpler, one-celled forms and ends with the most complicated, *i.e.*, birds and beasts, as it is believed that this is the most natural and philosophical method. In geological history the invertebrates, *i.e.*, those animals without a backbone, appeared before the vertebrates. It is better to lead the student from the simpler to the more complex animal forms, just as in studying history we begin with the origin of mankind and trace the history of the earlier nations which have preceded existing peoples; or in the history of our own country, begin with the discovery and first settlement by our European ancestors. To begin the study of zoology by first taking up the mammals and birds is like reading history backwards. Besides this, the student, being more familiar with the birds and mammals, will find the subject growing more interesting as he gets nearer the end of the book.

GENERAL WORKS ON ZOOLOGY.

T. H. Huxley. A Manual of the Anatomy of the Invertebrated Animals, 1877. A Manual of the Anatomy of the Vertebrated Animals, 1871.

C. Gegenbaur. Elements of Comparative Anatomy. 1878.

C. Claus. Elementary Text-book of Zoology. 2 vols. 1884–85.

A. Lang. Text-book of Comparative Anatomy. Pt. I. 1891.

Coues and Kingsley's Standard Natural History. 6 vols. 1884–85.

Also, Darwin's Origin of Species, and the works of Lamarck, Semper, Haeckel, Wallace, Weismann, and Eimer.

CHAPTER I.

Branch I.—Protozoa (*Animalcules, Infusoria, Monads, etc.*).

General Characters of Protozoans.—Few of the Protozoans can be seen without the aid of the microscope; they are microscopic animals or animalcules. One of the simplest forms is a very minute being called *Amœba*. It is to be sought for in standing pools, where it lives on the leaves or stems of submerged plants or in the mud or ooze at the bottom. Taking up a drop of water from the bottom of such a pond and placing it under high powers of the microscope, we may, after close examination, detect a very small moving mass of jelly-like substance or protoplasm. As it glides over the glass the sides of its body bulge out, or it suddenly throws out lobes or projections from various parts of its body as if it were falling apart; then it retracts these transparent root-like processes, which are called **pseudopodia**, or false feet, and becomes smooth and rounded, like a drop of thick syrup. Throughout the body-mass are granules which have a rude sort of circulation. There is also in or near the middle a clear round body called the **nucleus**. In all respects the Amœba is a *cell, i.e.*, a bit of protoplasm with a nucleus in the middle. Besides the nucleus, a clear, hollow, round, pinkish space which enlarges and contracts is usually present. This is called the "contractile vesicle."

The food of the Amœba consists of one-celled plants such as diatoms and desmids, and of portions of thread-like plants, or of animalcules. After selecting its food, as for example a minute plant, it engulfs or swallows it by moving towards the object and gradually closing around it,

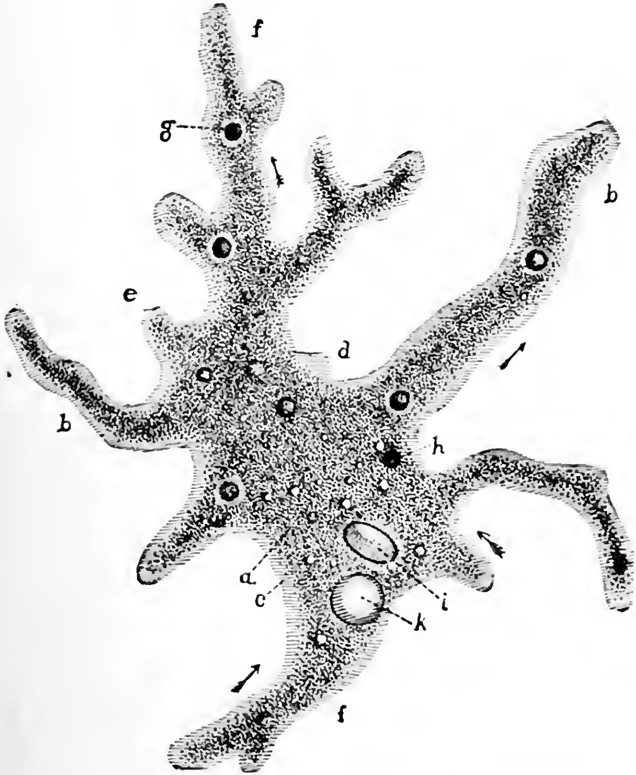


FIG. 1.—*Amœba proteus.* *a*, endosarc; *c*, ectosarc; *b*, simple pseudopod; *f*; branched pseudopod; *g*, food vacuole; *d*, a pseudopod beginning to grow out, *e*, one a little more developed; food vacuole; *h*, food-ball; *i*, nucleus; *k*, contractile vesicle. Magnified 200 diameters. After Brooks.

until the object is enveloped within the body, which is so transparent that the food-object can be seen through it.

The Amœba has the power of digesting and of distributing and absorbing the food (Fig. 1, *h*, food-ball) when digested.

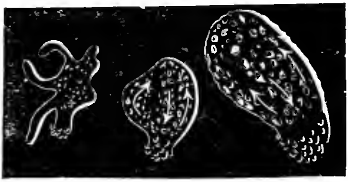


FIG. 2.—*Amœba proteus.* *A*, the left-hand figure, the most usual form; the right shows the broad, flat pseudopodia; the arrows indicate the direction of circulation of the granules. Highly magnified.

The Amœba reproduces its kind by simply dividing into two portions, as seen in Fig. 3. After becoming encysted or forming a round mass as at *B*, it breaks out of the cell-wall and becomes free and irregular in shape as at *A*. Self-division then begins as at *C*, the nucleus dividing into two, until at *Da* and *Db* two separate individuals are formed.

When the Amœba is touched it (1) contracts its body—it

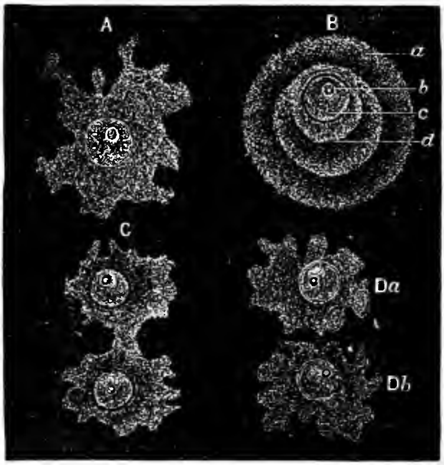


FIG. 3.—*Amœba sphærococcus.* *A*, before division. *B*, the same in its resting stage; *a*, cyst or cell-wall; *d*, body-mass; *c*, nucleus; *b*, nucleolus. *C*, Amœba; nearly divided. *D*, two young Amœbæ, the result of division. Highly magnified.

is thus said to be contractile—and (2) performs automatic movements; also, like the higher animals, (3) it swallows food; (4) chemical changes in the food take place: in other words, it digests its food, *i.e.*, separates or secretes the portion necessary to nourish its body from those portions which it rejects as waste; (5) it may also be said to breathe, the changes involved in taking food, especially oxygen, causing the production and excretion of carbonic acid; (6) and finally, it can reproduce its kind. Thus we have foreshadowed in this exceedingly simple organism all the important functions of animal life.

CLASSES OF PROTOZOA.

1. Body formless, usually shelled.... ....*Rhizopoda.*
2. Body cylindrical; parasitic....... ....*Gregarinida.*
3. Body ciliated.........................*Infusoria.*

CLASS I.—RHIZOPODA (*Root-animalcules*).

General Characters of Rhizopods.—Besides the *Amœba*, which is a representative of this class, there are a number

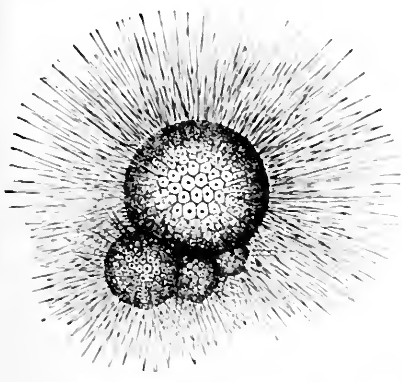


FIG. 4.—A Foraminifer. *Globigerina bulloides*, magnified 70 diameters.

of fresh-water forms which have simple, silicious shells; but in the sea there are thousands of species whose shells are partitioned into chambers, and are usually perforated with holes like a sieve, through which the animal protrudes its false feet or pseudopods. These shelled Rhizopods are called *Foraminifera* (Latin, *foramen*, a hole or aperture; *ferens*, bearing).

In some forms, as the fossil *Nummulites*, the chambers are numerous and regular, the shells being flat and consisting of eight coils situated in the same plane. A recent species of Foraminifer found at Borneo measures more than two inches in diameter, while a common form on the Florida reefs which is swallowed in large quantities by the *Holothuria*, or sea-cucumber, measures about one fifth of

Fig. 5.—*Rotalia*. A Rhizopod, showing the pseudopodia.

an inch in diameter. Most of our native species are much more minute. The *Eozoön*, so-called, is supposed by some to be a Foraminifer, but others regard it as of mineral origin. These Foraminifera float in calm weather on the surface of the sea, and when they die their shells slowly sink to the bottom. They are exceedingly abundant, and the shells at the bottom accumulate in such quantities as to make a gray mud or ooze forming the bottom of the ocean at great depths: this soft, deep mud is called *Globigerina* *ooze.* Chalk is largely made up of the calcareous shells of *Foraminifera;* before it became hardened into rock-masses it was a kind of Foraminiferous ooze.

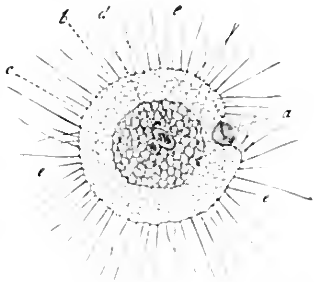


FIG. 6.—*Actinosphærium*, a Radiolarian. *a*, a morsel of food drawn into the cortical layer *b*; *c*, central parenchymatous mass of body; *d*, some balls of food-stuff in the latter; *e*, pseudopodia of the cortical layer. Highly magnified.

Those Rhizopods which secrete a silicious shell are called *Radiolaria*. A few (Fig. 6) live in fresh-water ponds, but the majority live in the sea. Their shells possess wondrous beauty and variety of ornamentation.

Some Rhizopods are known to develop from little monad-like or round germs, which move about by means of two little active threads or tails.*

CLASS II.—GREGARINIDA.

General Characters of Gregarines.—These may be best defined as parasitic, worm-like Amœbæ. They are long and slender, of quite definite flattened or cylindrical form (Fig. 7) to adapt them to their parasitic life. The largest kind (*Gregarina gigantea*) is like a piece of fine thread, half an inch long; it lives in the intestine of the lobster. Most Gregarinæ are very minute, and are parasites, living in the digestive canal of insects.

CLASS III.—INFUSORIA.

General Characters of Infusoria.—If we allow a little dried grass or hay or a piece of fish to stand in a glass of water for a day or two, thus making what is called an infusion, and then examine a drop of this water it will be found to teem with myriads of microscopic creatures, called Infusorians, because they are found in infusions. The simplest and minutest form of infusorian is the monad (Fig. 8).

* See Leidy's Fresh-water Rhizopods of North America, 1879.

In swimming, the monad stretches out the whip-lash-like appendage called the *flagellum*, which vibrates with an undulating, whirling motion, and produces a peculiar graceful rolling motion of the monad. When the monad is fixed the flagellum is used to convey food to the mouth, which lies between the base of the flagellum and beak, or "lip." The food is thrown by a sudden jerk, and with precision, directly against the mouth. "If acceptable for food, the flagellum presses its base down upon the morsel, and at the same time the lip is thrown back so as to disclose the mouth, and then bent over the particle as it sinks into the latter. When the lip has obtained a fair hold upon the food, the flagellum withdraws from its incumbent position and returns to its former rigid, watchful condition. The process of deglutition is then carried on by the help of the lip alone, which expands latterly until it completely overlies the particle. All this is done quite rapidly, in a few seconds, and then the food glides quickly into the depths of the body, and is enveloped in a digestive vacuole, whilst the lip assumes its usual conical shape and proportions." (Clark.)

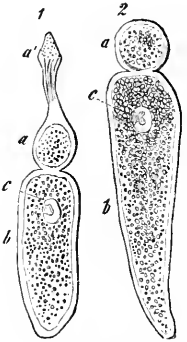


FIG. 7.—Gregarina from the alimentary canal of a beetle. 1, younger state, with a beak-like continuation (a') of the head. 2, older; a, anterior end; b, hinder part of the body; c, nucleus. Highly magnified.

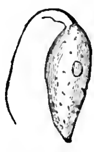


FIG. 8.—Uvella, a flagellate infusorian, or monad, with two large cilia called flagella. Greatly magnified.

Some monads are attached by a slender stalk to the leaves and stems of aquatic plants, and these are usually collected into compound monads, several arising from a common stalk. In such cases the body with its nucleus and two or three contractile vesicles is surmounted by a delicate collar, out of which the lash (flagellum) projects.

Monads multiply (1) either by self-division, or (2) by the production of great numbers of extremely minute germs. Hence the minutest of all beings reproduce from germs. It has been found that while a fully grown monad, called *Dallingeria*, may be destroyed at a temperature of 142° F., the germs or young, which are inconceivably minute, requiring to be magnified 3000 diameters in order to be seen, perish only when heated in fluid to from 212° F. to 268° F. It would thus appear that no living beings, either plant or animal, are exceptions to the universal law that all arise from germs. Hence the doctrine of spontaneous generation, which implies that the lower animals may at the present day develop spontaneously by chemico-physical action, is not true.

Some monads are phosphorescent. Such is the gigantic monad called *Noctiluca* (Fig. 9), which occurs in great num-

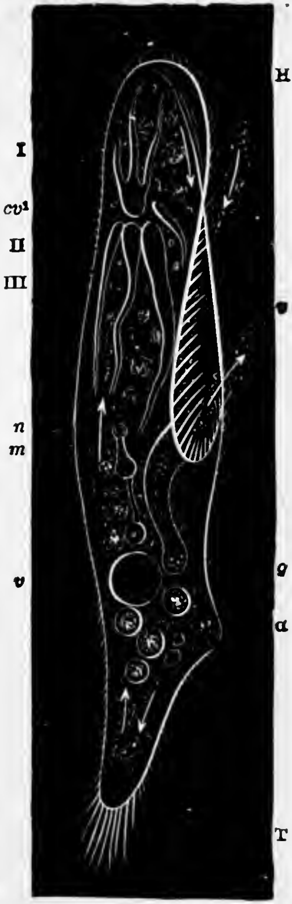


FIG. 10.—*Paramecium caudatum.* A view from the dorsal side, magnified 310 diameters. *H*, the head; *T*, the tail; *m*, the mouth; *m* to *g*, the throat; *a*, the posterior opening of the digestive cavity; cv^1, the anterior and *cv* posterior contractile vesicles; I, II, III, the radiating canals of cv^1; *n*, the reproductive organs; *v*, the large vibrating cilia at the edge of the vestibule.

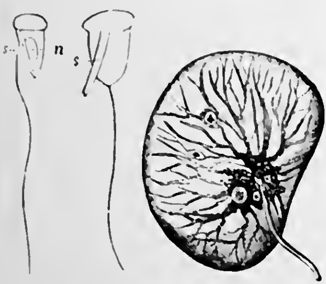


FIG. 9.—*Noctiluca miliaris*, diameter ¼ to 1mm, and its germs or zoospores. *s*, style; *n*, nucleus. Greatly magnified.

bers on the surface of the sea, and is large enough to be seen with the naked eye.

The true *Infusoria* are covered with *cilia,* or hair-like processes, by which they glide about over submerged leaves, etc. One of the largest and commonest Infusorians is *Paramecium.*

Fig. 10 represents *Paramecium caudatum.* This animalcule is a mass of protoplasm, representing a single cell. In the body-mass are excavated a mouth and a throat leading to a so-called stomach or digestive cavity. Two hollows in the body form the contractile vesicles, and another cavity constitutes the nucleus (*n*).

The trumpet-animalcule (*Stentor*) is large enough to be

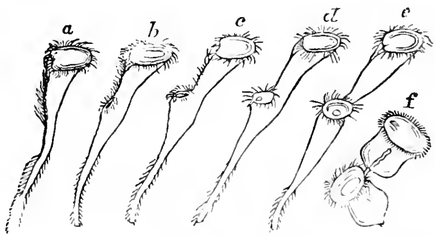


FIG. 11.—Process of fission in *Stentor polymorphus.* *b*, a new Stentor budding out; *e*, ready to separate from the original one; *f*, the two in a contracted state.

detected with the unaided eye. This Infusorian attaches itself at one end by a stalk, and builds up a slight tube, into which it contracts when disturbed. The Stentor may be sometimes observed multiplying by self-division.

In *Stentor polymorphus* the process of self-division takes place in two hours. Fig. 11, *f*, represents the final stage when the two individuals swim away separately, each assuming the original adult form, *a*.

The bell-animalcules, *Vorticella* and *Epistylis* (Fig. 12), form patches like white mould on aquatic plants. Their motions as they suddenly contract and shoot out their bells is exceedingly interesting.

Many Infusorians, besides self-dividing, produce ciliated young. Some Infusorians also undergo a process common in low plants, called "conjugation."*

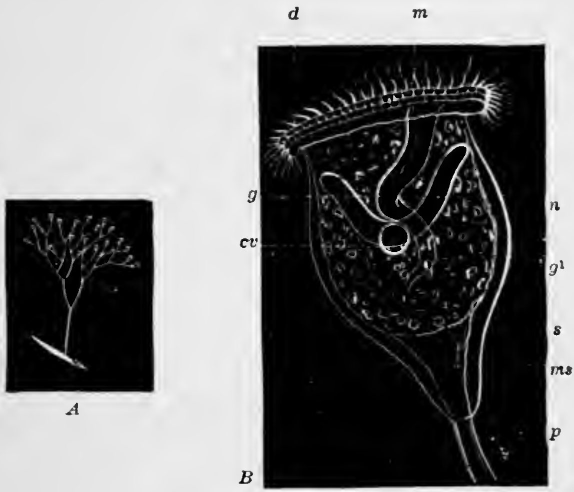


FIG. 12.—*A*, *Epistylis flavicans* Ehr., a single, many-forked colony of bell animalcules, slightly magnified. *B*, one of the animalcules magnified 250 diameters. *p*, the stem; *d*, the flat spiral of vibrating cilia at the edge of the disk; *ms*, the muscle; *m* to *s*, the depth of the digestive cavity; *m*, the mouth; *g*, g^1, the throat; *cv*, the contractile vesicle; *n*, the reproductive organ.

CHAPTER II.

BRANCH II.—PORIFERA (*Sponges*).

GENERAL CHARACTERS OF SPONGES.—Sponges are now known to be composed of numerous cells, arranged in three layers, the embryo arising from an egg, and passing through a blastula and a gastrula stage, as in all the higher animals.

A sponge, then, is a cellular sac (Fig. 13) with digestive chambers or minute rude stomachs lined with ciliated cells, the whole sponge-mass being propped up by an irregular basket-work of needle-like bodies called spicules. Upon cutting a dry sponge in half there are to be seen large canals which have large openings called *oscula;* these are really

* See Kent's Manual of the Infusoria, London, 1880–82.

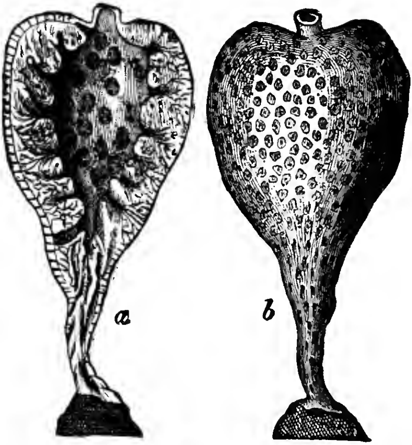


FIG. 13.—*a*, longitudinal section through a simple calcareous sponge, showing its simple central cavity; *b*, showing a single osculum at the top, and the many mouths over the surface. After Haeckel.

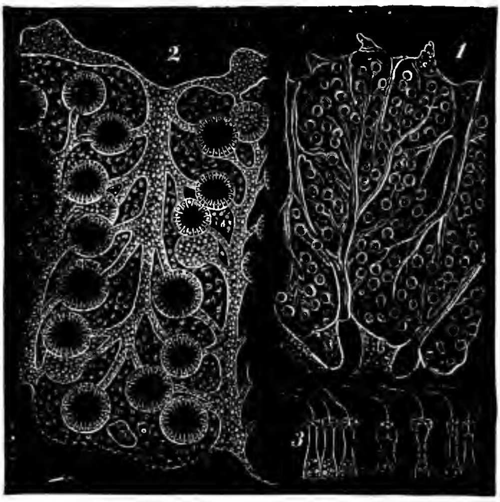


FIG. 14.—Microscopic section of a bit of sponge. 1, canals leading to the chambers; 2, section of the same enlarged; 3, the ciliated cells, highly magnified. From Lütken's Zoology.

openings for the exit of waste matters. Among these large openings are multitudes of minute openings which serve as mouths. These mouths lead by branching canals into little pockets or chambers which are lined with digestive, ciliated

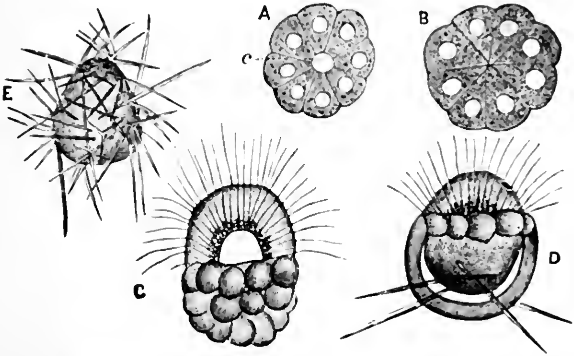


FIG. 15.—Development of a sponge (*Sycon ciliatum*). *A, B*, morula seen in section; *c*, segmentation cavity; *C*, blastula stage; *D*, gastrula about to become stationary, with a few spicules; *E*, sponge become stationary, with spicules. Highly magnified.

cells; the sponge, then, has myriads of mouths and stomachs (Fig. 14).

Sponges develop, like all the higher animals, from true eggs. The egg, after fertilization, begins to grow, and divides into two, four, eight, sixteen, and more spheres, until it looks like a mulberry, which seen in section is as in Fig. 15, *A, B*. This is the segmentation stage or *morula*. The cells farther multiply, and arrange themselves into a single layer, when the embryo is called a *blastula*. Some of the cells are ciliated, and as a blastula the embryo leaves the parent sponge and swims about in the sea (Fig. 16 and Fig. 15, *C*).

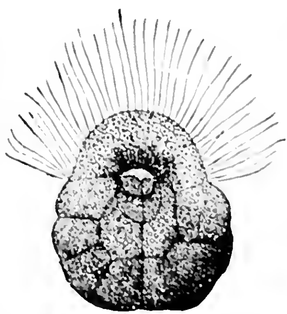


FIG. 16.—Ciliated embryo or blastula of a sponge (*Sycandra raphanus*). (Highly magnified.)

After invagination the blastula becomes a *gastrula* and fixed to the bottom, the spicules growing as in Fig. 15, *E.** Sponges may have horny spicules as in those in domestic use, or calcareous or silicious spicules. Fig. 17 represents a fine silicious sponge from the West Indies. The most

FIG. 17.—*Pheronema Annæ*, half natural size, with stellate and anchor-like spicules, much enlarged.

beautiful of all silicious sponges is the Venus' flower-basket (*Euplectellum aspergillum*), which lives anchored in the mud at the depth of about 10 fathoms, near the Philippine Islands.

A sponge called the *Cliona* bores into shells, causing them

* See Haeckel's Die Kalkschwämme. 3 vols. 1872.

to disintegrate. For example, *Cliona sulphurea*, a yellowish sponge, has been found by Verrill boring into various shells, such as the oyster, mussel, and scallop; it also spreads out on all sides, enveloping and dissolving the entire shell. It has even been known to penetrate one or two inches into hard statuary marble.

Of the marketable sponges there are six species, with numerous varieties. They are available for our use from being simply horny or fibrous, having no flinty or silicious spicules. The Mediterranean sponges are the best, being the softest; those of the Red Sea are next in quality, while our West Indian species are coarser and less durable. Our West Indian glove-sponge (*Spongia tubulifera*) corresponds to *Spongia Adriatica*, which is the Turkey cup-sponge and Levant toilet sponge of the Mediterranean. *Spongia gossypina*, the wool sponge of Florida and the Bahamas, is used as a horse or bath sponge.

CHAPTER III.

BRANCH III.—CŒLENTERATA (*Hydroids, Polyps, etc.*).*

GENERAL CHARACTERS OF CŒLENTERATES.—We now come to animals of more definite shape than sponges, while their structure is more easily understood. A common type or representative of the group is the fresh-water *Hydra*. Its body is like a slender cylindrical sack, with a mouth in the middle surrounded by a circle of feelers or tentacles. The mouth leads into a simple stomach-like cavity; whatever is not digested, such as pieces of shell, etc., is rejected from the mouth. The walls of this very simple body consist of two cell-layers, the *ectoderm* and *endoderm;* the middle layer (mesoderm), found in higher animals, not being present. From the fact that the digestive cavity or stomach is simple, being hollowed out of the body, there being no genuine separate digestive canal, as in the higher animals, all the species of this branch are called *Cœlenterata* (Greek, κοῖλος, hollow; and ἔντερον, digestive track).

* See the works of Darwin on Coral Reefs, Dana's Corals and Coral Islands, A. Agassiz's Seaside Studies in Natural History, 1871.

Class I.—Hydrozoa.

Characters of Hydrozoans.—The common Hydra (Fig. 18) may be found in fresh-water ponds attached by its base to the

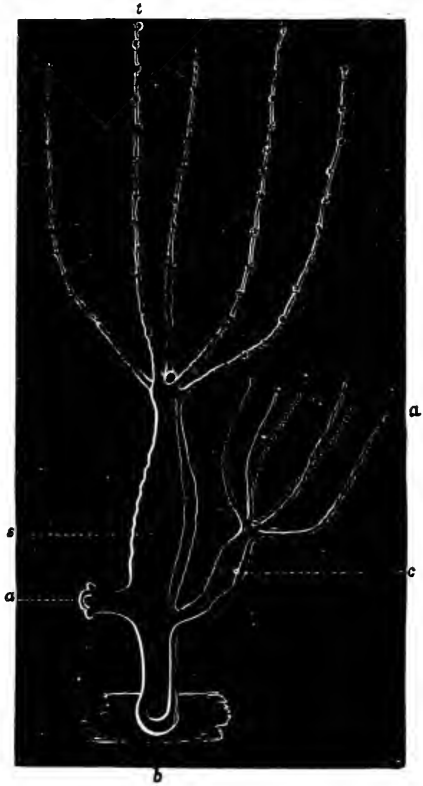


Fig. 18.—*Hydra fusca*, with two young (*a c*) budding from it; *b*, the base; *s*, the digestive cavity; *t*, tentacles. Magnified.

under side of the leaves of aquatic plants. It is not fixed permanently, but can move freely about. It is very small, just large enough to be seen without a magnifying glass; it is usually pale green, but is sometimes brown. The mouth is surrounded with from five to eight tentacles or feelers, which are hollow, the mouth opening into the central cavity or stomach. The Hydra, attached to some leaf, reaches its tentacles out in all directions; a minute insect or young snail or Infusorian passing by will, if touched by these feelers, be instantly paralyzed, and then the feelers close over the helpless victim and it is drawn into the stomach and digested. This power of paralyzing and thus easily capturing active living creatures is due to the presence in the skin of the tentacles and body of what are called lasso-cells or nettling organs (Fig. 20, *c*, *d*, *e*), which are minute cells containing a long barbed thread coiled up within the cell. When the Hydra touches an animal swimming near it, thousands of these little barbed cords are darted into the victim, which is instantly paralyzed, and thus falls an easy prey to its captor. These nettling organs are found in all Cœlenterates, such as jelly-fishes and coral polyps.

The Hydra, like some other animals of simple structure, is capable to a wonderful degree of reproducing itself when cut into pieces. Trembly, as early as 1744, not only cut Hydras in two, each part becoming a perfect Hydra, but on slicing them across into thin rings he found that from each ring grew out a crown of tentacles; he split them into longitudinal strips, each portion becoming eventually a well-shaped Hydra, and finally he turned some inside out, and in a few days the Hydra swallowed and digested bits of meat, its former stomach-lining having now become its skin. The Hydra reproduces by budding as well as by eggs.

The process of budding is but a modification of that involved in natural self-division, and it is carried on to a great extent in Hydra, a much larger number of individuals being produced in this way than from eggs. Our figure (13) shows two individuals budding out from the parent Hydra; the smaller bud (*a*) is a simple bulging out of the body-walls, the bud enveloping a portion of the stomach, until it becomes constricted and drops off, the tentacles meanwhile budding out from the farther end, and a mouth-opening arising between them, as at *c*. Budding in the Hydra, the Actinia, and other polyps, and in fact all the lower animals, is simply due to an increase in the growth and multiplication of cells at a special point on the outside of the body.

The Hydra, exactly as in the vertebrates, including man, arises from an egg which, after fertilization, passes through

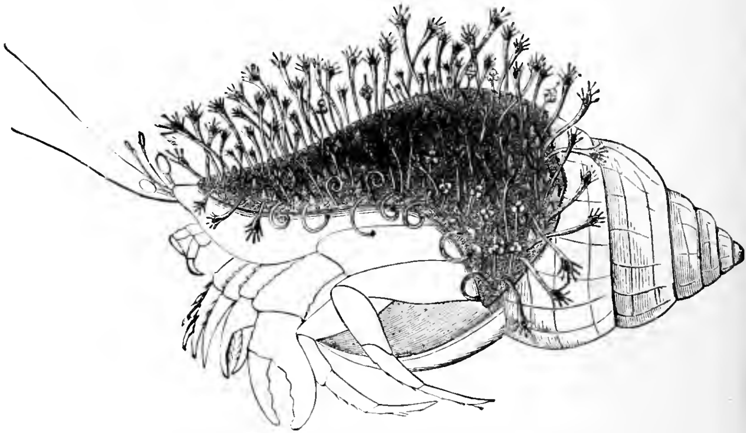


FIG. 19.—Colony of *Hydractinia echinata* on a shell tenanted by a hermit crab, natural size.

a blastula and then a gastrula stage, the germ consisting at first of two cell-layers.

In all the Hydroids except Hydra the sexes are separate, and we for the first time in the animal kingdom meet with two sorts of individuals, *i.e.*, males and females.

The simplest form next to Hydra is *Hydractinia*, a Hydroid encrusting shells (Fig. 19). In this form the individual is composed of three parts, each endowed with different functions, and called *zooids*—namely, *a*, hydra-like, sterile or nutritive zooids; *b* and *c*, the reproductive zooids, one male and the other female, both being much alike externally, having below the short rudimentary tentacles several round sacs, or "medusa-buds" which produce either male or female medusæ. These medusa-buds are like the free medusæ of *Coryne*. The marine Hydroids, then, are

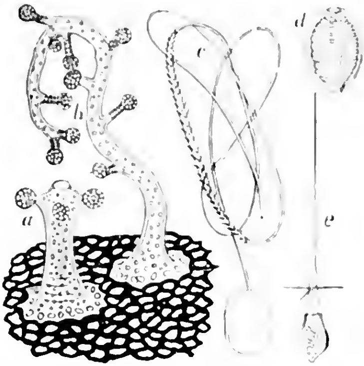


FIG. 20.—Animal of *Millepora nodosa*. *a*, nutritive zooid; *b*, reproductive zooid; *c*, lasso cell; *d*, the same coiled up in its cell; *e*, a third form. All highly magnified.

usually of distinct sexes, growing by colonies, which are either male or female.

The minute animals of *Millepora* secrete large coral-like masses on the reefs of Florida and the Pacific Ocean. The name is derived from the numberless minute holes or pores scattered over the surface in which the nutritive (Fig. 20, *a*) and reproductive zooids (Fig. 20, *b*) live. On breaking off pieces of the living coral one's hand is stung and made sore for days by the stings from the lasso-cells, so poisonous is this coral-like growth (Fig. 20, *c*, *d*, *e*).

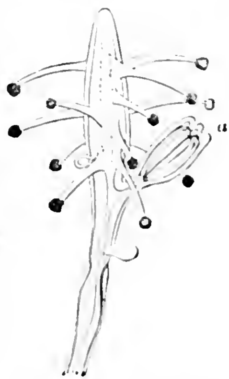


FIG. 21.—Polypite of *Coryne mirabilis*, with a medusa-bud at *a*. Much enlarged.

A common Hydroid on our northern shores is the *Coryne* (Fig. 21), which differs from the foregoing kinds in producing a free bell-like form called a *medusa* or jelly-fish (Fig. 22). All jelly-fishes are more or less bell or umbrella shaped, and are delicate transparent creatures which move about in the water, by opening and closing the edge of the disk-like body. From the centre of the body hangs down a hollow proboscis-like tube, the stomach, from the base of which radiate four canals or passages which open into a circular passage around the edge of the disk. This is the *water-vascular* system, and the fluid it contains is sea-water mixed with the digestive fluid; this fluid thus rudely corresponds to the blood of higher animals. Four long thread-like tentacles in the Coryne hang down from the edge of the disk. These delicate jelly-fishes possess a nervous ring passing around the edge of the disk, and also eyes and simple ears (*otocysts*) situated at intervals on the edge of the disk.

FIG. 22.—Free Medusa of *Coryne*, with the four long tentacles. Enlarged.

The medusæ arise from little bud-like swellings on the young or Hydroid (Fig. 21, *a*); these enlarge, and finally become detached and swim about as at Fig. 22.

Some Hydroids like *Sertularia* (Fig. 23) are encased in horn, and closely resemble delicate sea-weeds. They are commonly thrown upon sea-beaches.

Our common large jelly-fish or "sun-fish" so often thrown ashore on sandy beaches is the *Aurelia* (Fig. 27). It grows eight or ten inches in diameter. Its tough, jelly-like convex disk is smooth above, but hollowed out beneath into a broad stomach with a square mouth, the edge of which is minutely fringed, bearing four fringed broad, short tentacles. On the fringed margin are eight covered eyes situated in indentations, which divide the disk into eight slightly marked lobes. The four main water-vascular canals subdivide, as seen in Fig. 27, into numerous branches, which connect with the marginal vessel The Aurelia spawns late in the summer.

The eggs pass out of the mouth into the water along the channelled arms, and in October the ciliated sac or gastrula becomes pear-shaped and attaches itself to rocks, dead shells, or sea-weeds, and then assumes a Hydra form with often twenty-four very long tentacles. This stage was

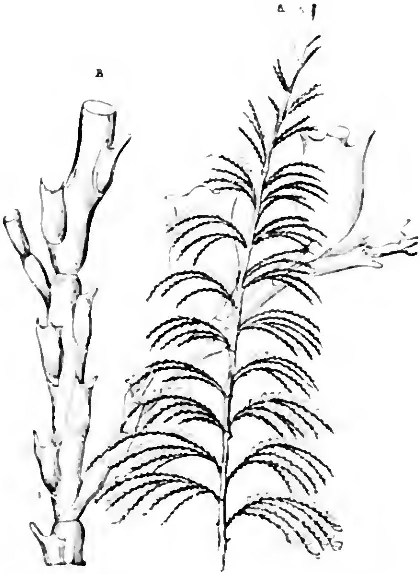


FIG. 23.—*Sertularia abietina* of Europe. *A*, natural size; *B*, magnified, showing the cells containing the animals.

originally described as a distinct animal under the name of *Scyphistoma*. In this Scyphistoma stage (Fig 24) it remains about eighteen months. Toward the end of this period the body increases in size and divides into a series of cup-shaped disks. These saucer-like disks are scalloped on the upturned edge, tentacles bud out, and the animal assumes the Strobila stage (Fig. 25). Finally, the disks separate, the upper one becomes detached and dies, but the others swim away in the *Ephyra* form (Fig. 26), when about a fifth of an inch in diameter, and toward the middle or end of summer become adult *Aureliæ* (Fig. 27).

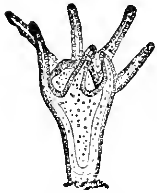


FIG. 24.—Scyphistoma of Aurelia.

FIG. 25.—Strobila of *Aurelia flavidula.* Magnified.

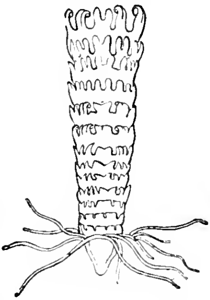


FIG. 26.—Ephyra or earliest free condition of Aurelia. Magnified.

An example of the compound Hydroids, called *Siphonophora,* is the *Physalia,* or Portuguese man-of-war (Fig. 28), which is common in the tropics, and is sometimes carried

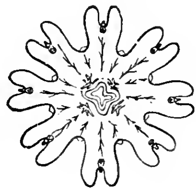


FIG. 27.—*Aurelia flavidula.* Natural size.

northward by the Gulf Stream. It is excessively poisonous to the touch. In picking up specimens stranded on the shores of Key West, Florida, our hands have been severely stung by them, the burning, smarting pain lasting for hours.

A Siphonophore, such as Physalia, for example, may be compared to a colony of Hydractinia, in which there are nutritive and reproductive zooids and medusa buds. In Physalia, however, there are four kinds of zooids—*i.e.*, (1) locomotive, and (2) reproductive, with (3) barren medusa buds, which are called the "swimming bells," and (4) the nutritive zooids or "feeders," a set of digestive tubes which nourish the entire floating colony.

FIG. 28.—*Physalia*, or Portuguese man-of-war. Natural size.

The Portuguese man-of-war consists of long locomotive tentacles, which, when the animal is driven by its broad sail or float before the wind, stretch out in large individuals from thirty to fifty feet. These large Hydra-like zooids are arranged in small groups, arising from a hollow stem communicating with the stomach extending between the inner and outer wall of the float. The "feeders" are of two kinds, large and small, and are clustered in branches growing from a common hollow stem, also communicating with the stomach.

CLASS II.—ACTINOZOA (*Sea-Anemones and Coral Polyps*).

General Characters of Actinozoans.—The Actinia or sea-anemone is the type of this class, the different kinds of

Actinians and coral polyps having the same general shape and structure.

The common Actinia of our coast (*Metridium marginatum*, Fig. 29) is to be found between tide-marks on rocks under sea-weeds, or in tidal pools, but grows most luxuriantly on the piles of bridges. It readily lives in aquaria, where its habits may be studied. An aquarium may be improvised by using a preserve-jar or glass globe, covering

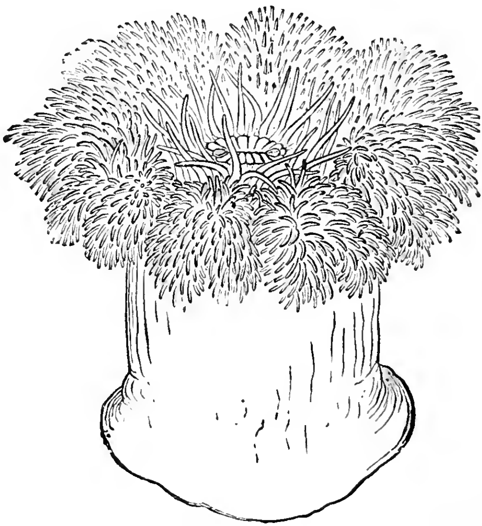


FIG. 29.—Common Sea-Anemone. Natural size, with the tentacles expanded. After Emerton.

the bottom with sand, with a large flat stone for the attachment of the sea-anemone. By placing a green sea-weed attached to a stone in the jar, and filling it with sea-water, the animal may be kept alive a long time.

After observing the movements of the crown of tentacles as they are thrust out or withdrawn, and the eye-spots at the base of some of the tentacles, specimens may be killed expanded by the gradual introduction of fresh water, or by plunging them into picric acid. They should then be transferred to the strongest alcohol, and allowed to soak in it for two or three days until the tissues become hard enough to cut well. Then vertical and transverse sections may be made with a sharp knife. The first fact to ob erve is, that an alimentary canal is much more clearly indicated than in the *Hydrozoa*, there being a distinct digestive sac, separate from the body-walls, hanging suspended from the mouth-opening, and held in place by six partitions (*mesenteries*), which divide the body cavity into a number of chambers. The digestive sac is not closed, but is open at the bottom of the body, connecting directly with the chambers, so that the chyme, or product of digestion, passes down to the floor of the body, and then into each of the chambers. On the free edges of the shorter mesenteries, which do not extend out to the stomach, there is a mass of long coiled filaments, the mesenterial filaments (Fig. 30, *cr*), which contain lasso-cells. In dissecting the sea-anemone these mesenterial filaments are always more or less in the way, and have to be carefully removed so as to expose the ovaries and adjoining parts. They press out of the mouth and *cinclides* (*ci*, small openings through the body-walls), not always present, and end of the tentacles, and thus come in contact with animals forming their food. The figure shows at the base of the body the free edges of the mesenteries (*m*) of different heights, with the spaces between them through which the chyme passes into the body-cavity. For the complete passage of the circulating fluid the six primary mesenteries are perforated by a large orifice (*op*) more or less oval or kidney-shaped in outline (Fig. 30). The digestive sac is divided into two divisions, the throat and stomach proper, the latter when the animal is contracted being much shortened, and with the walls vertically folded, as seen in the cut.

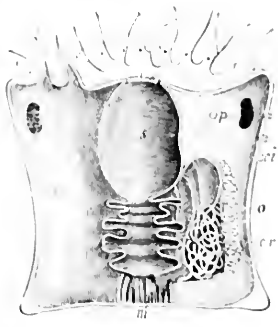


FIG. 30. Partly diagrammatic sketch of the anatomy of an Actinia (*Metridium*) with the tentacles disproportionately enlarged: *s*, œsophagus; *m*, mesenteries, or septa; *o*, ovary; *ci*, cinclides; *cr*, mesenteral filaments; *e*, eyes; *op*, orifice through the septa.

In the tentacles are lodged the lasso-cells, and the tentacles are hollow, communicating direct'y with a chamber or space between the mesenteries, and are open at the end. When a passing shrimp, small fish, or worm comes in contact with these tentacles, the lasso-threads are thrown out, the victim is paralyzed, other tentacles assist in dragging it into the distensible mouth, where it is partly digested, and the process is completed in the second or lower division of the digestive canal. The bones, shells, or hard covering of the animals which may be swallowed by the Actinia are rejected from the mouth after the soft parts are digested.

Sea-anemones have been found to have a slight sense of smell. Nearly all sea-anemones, besides arising from eggs, increase by budding, new individuals arising at or near the base of the large one.

The coral polyps only differ from the sea-anemones in secreting a limestone support or coral-stock. Corals are either cup-shaped and single, or are compound, forming

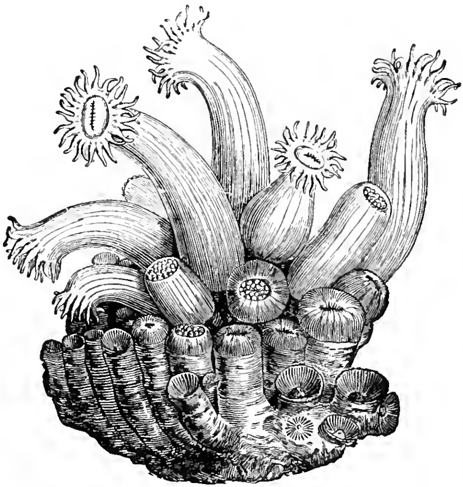


FIG. 31.—Coral polyp (*Astroides calycularis*) expanded. From Lütken's Zoology.

branching or rounded masses. The soft parts are supported by limestone partitions secreted in the chambers of the polyp.

All Actinozoans develop from eggs, and at first appear as little oval, ciliated, free-swimming embryos (*gastrulæ*), which eventually become attached to the bottom of the sea.

Before the embryo becomes fixed and the tentacles arise, the lime destined to form the partitions begins to be deposited. Fig. 32, *C*, shows the twelve rudimentary partitions. These, after the young polyp has become stationary, finally enlarge and become joined to the external walls of the coral now in course of formation (Fig. 32, *C*), forming a groundwork or pedestal on which the polyp rests. *D* represents the young polyp resting on the limestone pedestal, with the tentacles well developed.

But little is positively known as to the rate of growth of corals. A common brain coral (*Mæandrina labyrinthica*), measuring a foot in diameter and four inches thick in the most convex part, attained its growth in twenty years.

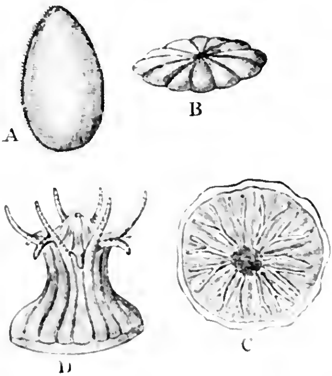


FIG. 32.—Development of a coral polyp, *Astroides calycularis*. *A*, ciliated gastrula; *B*, young polyp with 12 septa; *C*, *D*, young polyp farther advanced, with 12 tentacles; *C*, the corallum and limestone septa beginning to form. Magnified.

To the order of alcyonoid corals, which have but eight tentacles, belong the "sea-fans," "sea-pens," etc. In the family of sea-fans (*Gorgonidæ*) the coral-stock is horny or calcareous, branching tree-like, or forming a flat network. *Gorgonia flabellum* is red or yellow, and abundant on the Florida reefs. In the Arctic seas and the deeper, colder waters of the Newfoundland Banks and St. George's Banks, *Primnoa reseda* and *Paragorgia arborea* grow; the latter being of great size, the stem as thick through as one's wrist, and the whole corallum over five feet in height.

The common red coral (*Corallium rubrum*) of the Mediterranean Sea is worked into various ornaments. The coral fishery is pursued on the coasts of Algiers and Tunis, where assemble in the winter and spring from two hundred to three hundred vessels. The coral fishermen, with large rude nets, break off the coral from the submerged rocks. About half a million dollars' worth of coral is annually gathered.

FIG. 33.—High volcanic island with a barrier and fringing reef.

Of the larger corals the *Madreporaria* in the main are the true reef-builders. They are confined to waters in which through the coldest winter months the temperature of the water does not fall below 68° F., though usually the waters are much warmer than this, the mean annual temperature being about 73½° F. in the North Pacific and 70° F. in the South. Coral reefs are abundant in the West Indies, but still more so in the Central Pacific, where there are a much greater number of species of corals. Along the Brazilian coast, as far south as Cape Frio, are coral reefs. In depth living coral-reef-builders do not extend more than fifteen or twenty fathoms below the surface.

Coral reefs are divided by Dana into outer or barrier reefs (Fig. 33) and inner reefs. The barrier reefs are

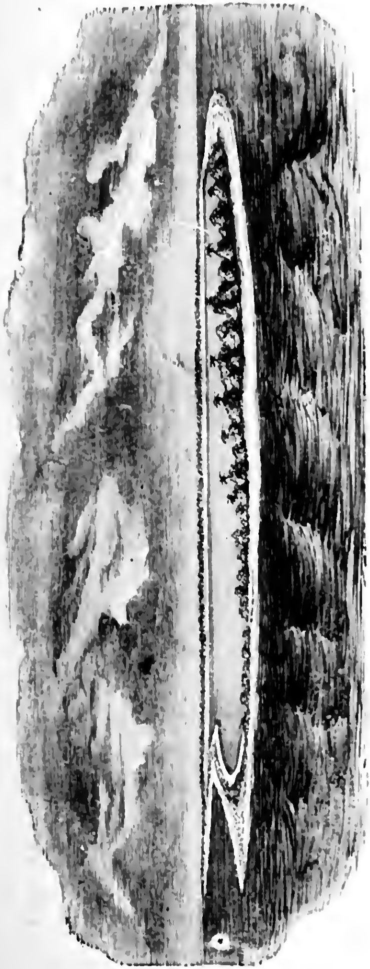


Fig. 31, A.—Coral island or atoll.

Fig. 31, B.—Section of a reef

formed from the growth of corals exposed to the open seas, while the inner or fringing reefs (Fig. 33) are formed in quiet water between a barrier reef and the island. As coral reefs are usually built upon islands which are slowly sinking, barrier reefs are simply ancient fringing reefs formed when the island stood higher above the sea, hence they are built up as rapidly as the land sinks, and thus the top of the reef keeps at the level of the sea. The reefs are often of great thickness, for, as Dana says, "could we raise one of these coral-bound islands from the waves, we should find that the reefs stand upon the submarine slopes, like massy structures of artificial masonry; some forming a broad flat platform or shelf ranging around the land, and others encircling it like vast ramparts, perhaps a hundred miles or more in circuit." Darwin has estimated that some reefs in the Pacific Ocean are at least 2000 feet in thickness.

Thus far we have spoken of reefs surrounding mountainous islands; coral islands or *atolls* (Fig. 34, *A*) resemble such reefs, except that they surround a lake or lagoon instead of a high island, the coral island itself being seldom more than ten or twelve feet above the sea, and usually supporting a growth of cocoanut trees, while the sea may be of great depth very near the outer edge of the atoll, which "usually seems to stand as if stilted up in a fathomless sea" (Dana). These reefs and atolls are formed and raised above the sea by the action of the winds and waves, in breaking up the living corals, comminuting it, and forming, with the débris of shells and other limestone-secreting animals and plants, banks or deposits of coral mixed with a chalky limestone, as the base of the reef. When it rises above the waves, cocoanuts and other seeds are caught and washed up on the top, and gradually the island becomes large enough to support a few human beings. The Bermudas are the remnants of a single atoll, and are situated farther from the equator than any other reefs. Some barrier reefs and coral islands or atolls are formed in an area of subsidence, where the bottom of the ocean is gradually sinking; this accounts for the peculiar form and great thickness of many reefs. On the other hand, the coral reefs of the West Indies are, generally speaking, in an area of elevation.

A section of a coral reef is shown by Fig. 34, *B*: *n* is the point where the shore slopes rapidly down within the lagoon (which lies to the right), and *m* is where the reef suddenly descends toward the open ocean. Between *b c* and *d e* lies the higher part of the reef. The shore toward the lagoon slopes away regularly from *d* to *n*; while toward the open ocean there is a broad horizontal terrace (*a* to *b c*) which becomes uncovered at low water.

Darwin's theory of the formation of barrier reefs is shown by the diagram (Fig. 35). The island, for example, the volcanic island Coro, which is slowly sinking, at the ancient sea-level I is surrounded by a fringing reef *f f*, a small

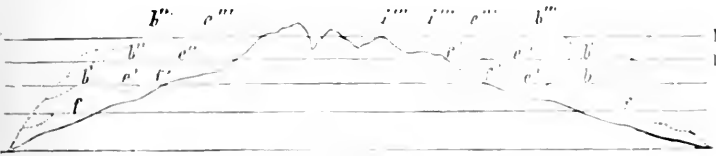


Fig. 35.—Schematic section of an island with reefs.

rock-terrace at the former level of the sea. Where the island has sunk to the level of the water-line II, the reef appears at the surface as at *b′ f′*, *b f*. There is now a fringing and a barrier reef, with a narrow canal between them; *b′* is a section of the barrier reef, *c′* of the canal or lagoon, and *f′* of the fringing reef. After a farther submergence to the sea-level III, the canal *c″* becomes much wider. On one side (*f f*) the reef is present, on the other side it has disappeared, owing to the agency of ocean-currents. Finally, at the water-level IV, there are two small islands surrounded by a wide lagoon, with two reef-islets *i‴*, *i‴*, resting upon two submarine peaks. The coral reef has now grown to great dimensions, and covered almost the entire original island, and though the reef-building coral polyps cannot live below a point fifteen or twenty fathoms below the surface, yet owing to the slow sinking of the island, they build up the reef as rapidly as the former subsides, and in this way after many centuries a coral reef sometimes two thousand feet thick may be built up in mid-ocean.

Without doubt ocean currents modify the forms of coral islands and reefs, and have much to do with their arrangement and distribution.*

Class III.—Ctenophora (*Comb-bearers*).

General Characters of Ctenophores.—These beautiful animals derive their name from the vertical rows of comb-like paddles (ctenophores), situated on meridional bands of muscles which serve as locomotive organs. Their digestive tract passes through the body, with two posterior outlets.

Our commonest example of this class is the *Pleurobrachia rhododacyla.* It is a beautiful animated ball of transparent jelly moving through the water by means of eight rows of minute paddles, throwing out from a sac on each side of the body two long ciliated tentacles. It is abundant in autumn; sometimes thousands may be seen stranded on the shore at low water.

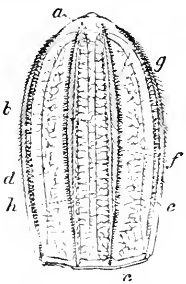


Fig. 36.—*Idyia roseola*, natural size. *a*, anal opening; *b*, lateral canal; *c*, circular canal; *d*, *e*, *f*, *g*, *h*, rows of paddles.

In *Bolina alata* the body is plainly bilateral and the water-vascular tubes are very distinct. In *Idyia roseola* (Fig. 36) the mouth is large, the stomach wide, and the body is of an intense roseate hue. This beautiful species after death, late in summer, is very phosphorescent; all Ctenophores, however, even their eggs and embryos, are phosphorescent.

* See Semper's Animal Life, A. Agassiz's Three Cruises of the Blake (vol. i), and the works of others who deny the theory of Darwin and of Dana, that subsidence is necessary to account for the formation of atolls, and claim that they are due to ocean currents, wave action, etc., subsidence only being necessary in the formation of reefs over one hundred feet thick.

CHAPTER IV.

BRANCH IV.—ECHINODERMATA (*Star-fish, Sea-urchins, Sea-cucumbers, etc.*

GENERAL CHARACTERS OF ECHINODERMS.—We now come to animals of much more complicated structure than any of the foregoing branches, and in which the radiated arrangement of the parts of the body is in most cases as marked as the jointed or ringed structure of worms or insects; for not only are the body-walls of the star fish or sea-urchin, or even many of the Holothurians (though less plainly), divided into five wedge-shaped portions, or produced into five arms as in the common star-fish or five-finger, but the nervous system, the reproductive organs, the blood and water-vascular systems, and the locomotive organs, are usually arranged in accordance with the star-like form of the body. The most trenchant character which separates the Echinoderms from the Cœlenterates, and allies them to the worms, is the genuine tube-like digestive canal which lies free in the body-cavity, and may be several or many times the length of the body.

The student can gain a correct idea of the general structure of the Echinoderms from a careful examination of the common star-fish (*Asterias vulgaris*), which is the most common and accessible Echinoderm to be found on the New England shores. After placing a star-fish in some sea-water and noticing its motions, the thrusting out of the ambulacral feet or suckers by which it pulls or warps its clumsy body over the mussel-beds, or rocks, or weeds, the arms being capable of slightly bending; after observing the red eye spot at the end of each arm or ray, and the movements of the numerous spines which are attached by a sort of ball and-socket joint to the calcareous framework of the body-walls, and examining the movements of certain modified spines called *pedicellariæ*, which are pincer-like bodies situated among the spines, the student will be ready to study the external and internal anatomy.

First, as to the calcareous framework of the star-fish. In order to study this, a transverse section should be made through an arm, and a vertical one through the body and along the middle of a single arm, and finally the animal should be divided into two halves, an upper and lower. It will then be seen that the calcareous framework or so-called skeleton consists of a great number of limestone plates or pieces attached by a tough membrane and covered by the skin. Between the plates are small apertures by which the water enters the body-cavity. These plates are arranged so as to give the greatest strength and lightness to the body. There is also to be seen an oral (under) side on which the mouth is situated, and an aboral (upper) side. Each arm or ray is deeply channelled by the "ambulacral furrow" containing four rows of suckers or "ambulacral feet,' which are tentacle-like protrusions of the skin growing out through

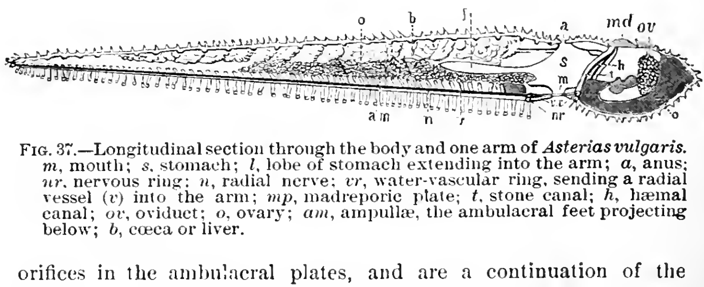


FIG. 37.—Longitudinal section through the body and one arm of *Asterias vulgaris*. *m*, mouth; *s*, stomach; *l*, lobe of stomach extending into the arm; *a*, anus; *nr*, nervous ring; *n*, radial nerve; *vr*, water-vascular ring, sending a radial vessel (*v*) into the arm; *mp*, madreporic plate; *t*, stone canal; *h*, hæmal canal; *ov*, oviduct; *o*, ovary; *am*, ampullæ, the ambulacral feet projecting below; *b*, cœca or liver.

orifices in the ambulacral plates, and are a continuation of the water-sacs or "ampullæ" within. The "madreporic plate" is a flattened hemispherical body situated on the disk between two of the arms. It is perforated by cañals.

We are now ready to examine the internal organs and to study their relations to one another and to the body-walls. The nervous system may be seen without dissection. By closely examining the mouth a pentagonal ring is seen surrounding it, each angle slightly enlarging and sending off a nervous cord to the eye at the end of the ray. It may be discovered by pressing apart the ambulacral feet along the median line of each arm. Fine nerves are sent off to each sucker, passing through the opening between the calcareous plates and extending to each ampulla, thus controlling the movements of the suckers. The visible nerves belong to a nervous subcutaneous sheet.

The mouth (Fig. 37, *m*) is capacious, opening by a short œsophagus into a capacious stomach (Fig. 37, *s*) with thin distensible walls, and sending a long lobe or sac (Fig. 37, *l*) into the base of each arm each sac is bound down by two retractor muscles attached to the median ridge lying between the two rows of water-sacs (ampullæ, see also Fig. 38). The stomach ends in a short intestine, the limits between the two not distinctly seen. The intestine suddenly contracts and ends in a minute rectum situated in an angle between two of five fleshy ridges radiating from the centre of the disk. Appended to the intestine are the "cœca" or "liver" (Fig. 37, *b*), consisting of two long, tree-like masses formed of dense branches of from four to six pear shaped follicles, connecting by a short duct with the main

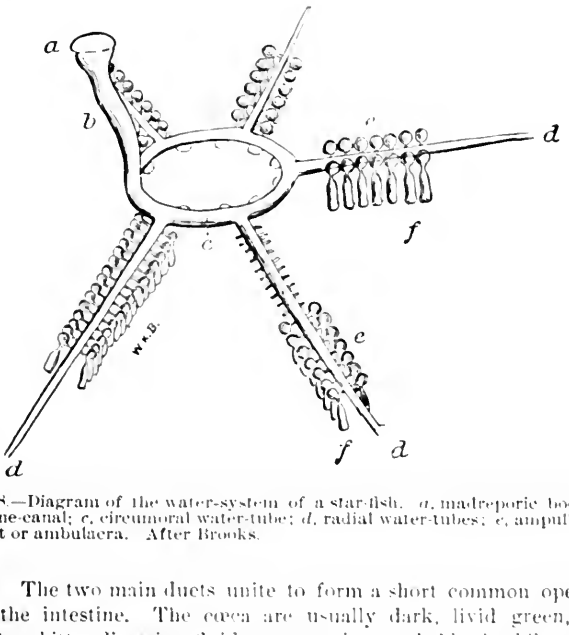


FIG. 38.—Diagram of the water-system of a star-fish. *a*, madreporic body; *b*, stone-canal; *c*, circumoral water-tube; *d*, radial water-tubes; *e*, ampullæ; *f*, feet or ambulacra. After Brooks.

stem. The two main ducts unite to form a short common opening into the intestine. The cœca are usually dark, livid green, and secrete a bitter digestive fluid, representing probably the bile of the higher animals.

The ovaries (Fig. 37, *o*) are long racemose bodies lying along each side of the interior of the arms, and the eggs are said to pass out by short narrow oviduct (*ov*) through an opening between two plates on each side of the base of the arms, the opening being small and difficult to detect.

The water-vascular system consists of the madreporic body, the "stone-canal" (Fig. 37, *t*), the ring or circumoral canal (*cr*), and the ra dial vessels (v) ending in the water-sacs (am) and ambulacral feet. The stone-canal begins at the outer and under side of the sieve-like madreporic body, passing directly forward and downward in a sinuous course to the underside of the circumoral plates. The madreporic body (mb) is externally seen to be perforated by linear apertures radiating and subdividing toward the periphery. The sea-water in part enters the body-cavity through the fissures in the madreporic body, while most of it enters the stone-canal, which is a slender tube scarcely one fourth the diameter of the entire madreporic body. The water entering the stone-canal (Fig. 37, t) passes directly into the water-vascular ring (Fig. 37) and then into the ten Polian vesicles and the five radial canals, whence it is conveyed to each water-sac or ampulla (Fig. 38, c; compare also Fig. 37). These pear-shaped water-sacs, when contracted, are supposed to press the water into the long slender suckers or ambulacral feet, which are distended, elongated, and by a sucker-like arrangement at the end of the prehensile foot act in conjunction with the others to warp or pull the star-fish along. Besides locomotion, the ambulacral feet serve for respiration and perception. The star-fish has the sense of smell.

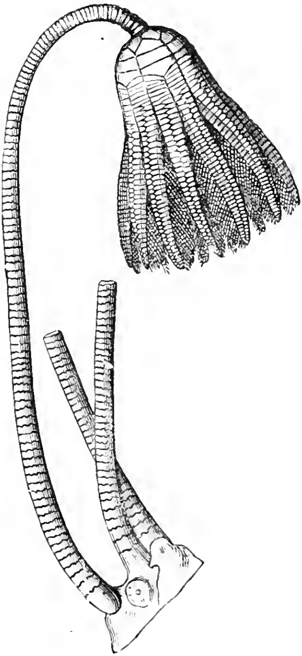


Fig. 39—Encrinus or Stone lily.

It will thus be seen that the water-vascular system in the star-fish is in its functions partly respiratory and partly locomotive, while it is in connection with the vascular system, and thus partly aids in circulating the blood and chyle. There is, besides, a complicated system of true blood-vessels, which are, however, difficult to discover.

Class I.—Crinoidea (*Stone-lilies, Encrinites, etc*).

General Characters of Crinoids.—These are stalked star-fishes, the stalk or stem being jointed. Most Crinoids are extinct or fossil; such is the Stone-lily (Fig. 39).

CLASSES OF ECHINODERMATA.

1. Body mounted on a stalk.............................*Crinoidea.*
2. Body with five arms; free ....*Asteroidea.*
3. Body spherical, with long spines......................*Echinoidea.*
4. Body elongated; skin soft, hardened by minute plates. *Holothuroidea.*

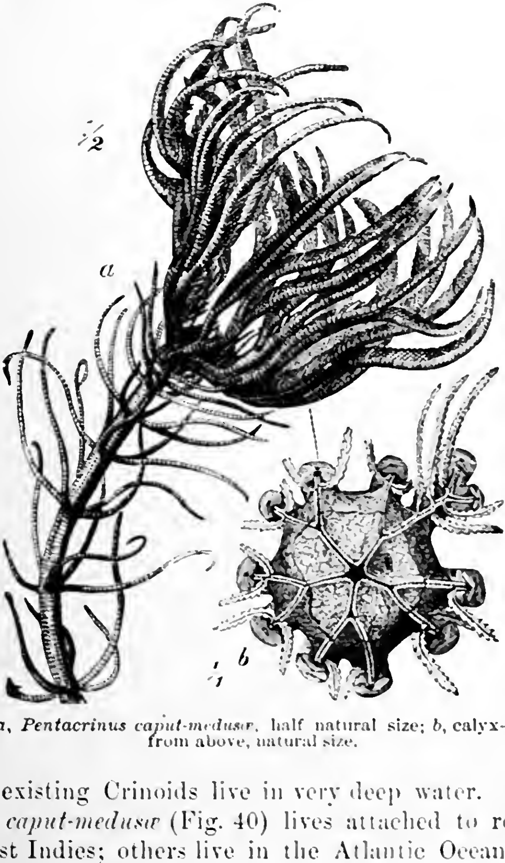


FIG. 40.—*a*, *Pentacrinus caput-medusæ*, half natural size; *b*, calyx-disk seen from above, natural size.

The existing Crinoids live in very deep water. *Pentacrinus caput-medusæ* (Fig. 40) lives attached to rocks in the West Indies; others live in the Atlantic Ocean, sometimes at the great depth of nearly three miles. A free Crinoid (*Antedon*, Fig. 41) lives in rather shallow water,

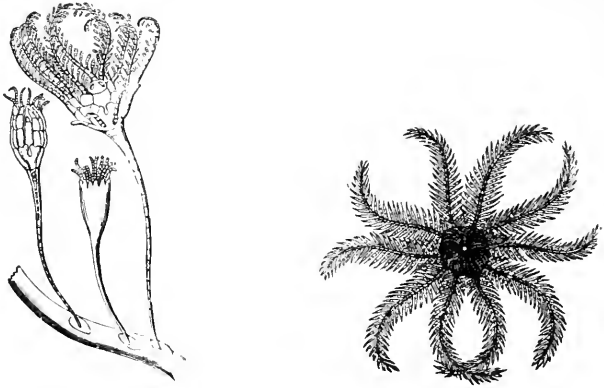


FIG. 41.—*Antedon*, stalked and free.

attached to rocks; stalked when young, it eventually becomes free.

CLASS II.—ASTEROIDEA.

General Characters of Star-fishes.—The star-fishes include the snake- or sand-star (Fig. 42), and the common five-finger, *Asterias vulgaris* (Fig. 43). This and the allied varieties are abundant on mussel and oyster beds, being very injurious to the latter, which serve them as food. The star-fish projects its capacious stomach between the open valves of the oyster, and sucks in the soft parts, in this way doing much damage to the oyster-beds of the southern coast of New England.

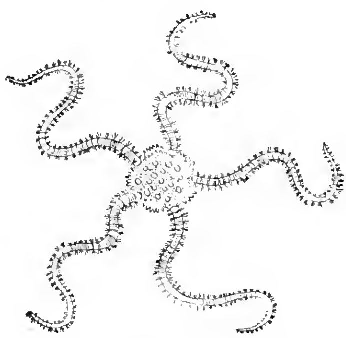


FIG. 42.—Sand-star. Natural size.

All star-fishes grow from eggs. After swimming about as a little ciliated sack (*gastrula*), arms grow out, and it appears much as in Fig. 45.

The young or larva has now both sides of the body alike. At this time two lobes arise from each side of the mouth. These separate from their attachment and form two distinct hollow cavities, and by the time the larva attains what is called the *Brachiolaria* stage, the development of the body of the star-fish begins, for these two cavities subsequently develop into two water-tubes. On one of these cavities the back of the star-fish is afterward developed, while on the other the under side with the feet or tentacles

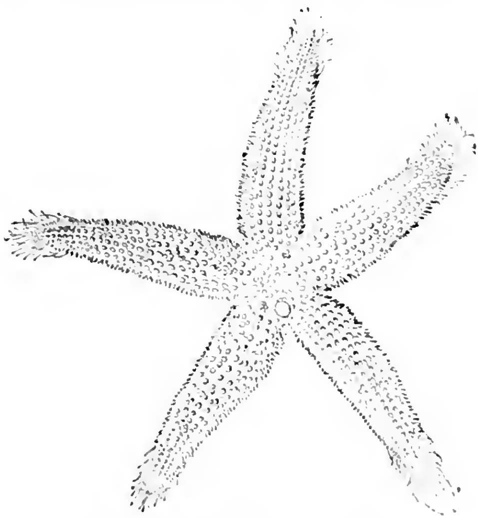


FIG. 43.—*Asterias vulgaris*, natural size.

arise. The fully-grown larva is called a *brachiolaria*, as it was originally described with this name under the impression that it was an adult animal. Fig. 45 shows the young star-fish growing in the posterior end of the larva or young, whose body it is now beginning to absorb; finally, the larva body disappears. At this time the star-fish is still minute, conical disk-shaped, with a crenulated edge. In this condition it remains probably two or three years before the arms lengthen and the adult form is assumed.

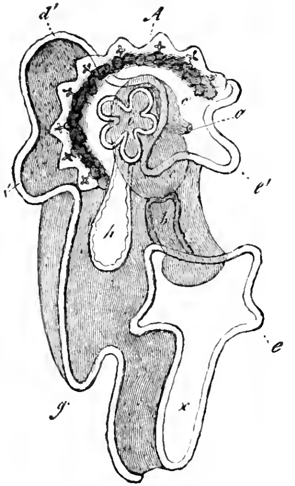


FIG. 44.—*Bipinnaria* with the star-fish budding from it. *e*, *e'*, *d'*, *g*, *g'*, protuberances of the body comparable with the "arms" of the Brachiolaria figured in the adjoining engraving. *b*, mouth; *o*, vent of the larva; *A*, germ of the star-fish; *h*, ciliated digestive tract; *i*, ambulacral rosette (germ of the water-vessels).

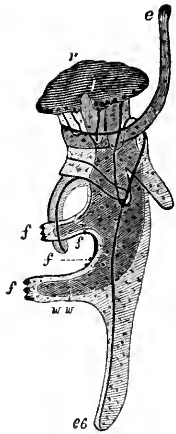


FIG. 45.—Brachiolaria of *Asterias vulgaris*, enlarged, with the star-fish (*r*) developing at the aboral end. *e*, median anal arm; e^6, odd terminal oral arm; *f*, brachiolar arm; *f*, branch of water-tube (*ww'*) leading into *f'* odd brachiolar arm; *f'''*, surface warts at base of odd brachiolar arm

CLASS III.—ECHINOIDEA (*Sea-urchins*).

General Characters of Sea-Urchins.—A good idea of the general structure of sea-urchins may be obtained by an examination of the common sea-urchin, *Echinus* (Fig. 46),

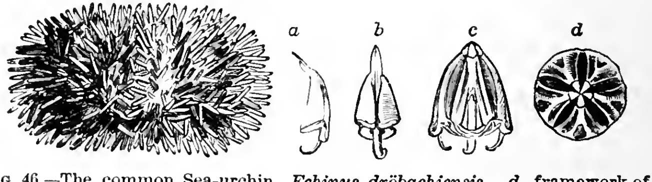


FIG. 46.—The common Sea-urchin. *Echinus dröbachiensis*. *d*, framework of mouth and teeth seen in front; *c*, the same seen sideways; *a*, *b*, side and external view of a single tooth (pyramid); all natural size.

of the eastern coast of the United States, Northern Europe, and the Arctic Seas. It is common among rocks, ranging from low-water mark to fifty or more fathoms. It eats sea-weeds, and is also a scavenger, feeding on dead fish, etc. We have observed great numbers of them assembled in large groups, feeding on fish offal, a few fathoms below the surface, in a harbor on the coast of Labrador, where fishing vessels were anchored.

FIG. 47.—*Echinarachnius parma*, common Sand-cake. Natural size.

On placing an Echinus in sea-water the movements of the animal, especially its mode of drawing itself along by its numerous long tentacles, and how it covers itself by drawing together bits of sea-weed and gravel, may be observed. It has button-shaped organs of smell and taste.

The shell consists of five double rows of limestone pieces called *ambulacral plates*, which are perforated for the exit of the tentacles or feet, which are like those of star-fish. There are also five double rows of *interambulacral plates*, to which the spines are attached. The sand-cake urchin (Fig. 47) is very flat, with minute spines.

CLASS IV.—HOLOTHUROIDEA (*Sea-cucumbers, Trepang*).

General Characters of Holothurians.—We now come to Echinoderms in which the body is usually long, cylindrical, with a tendency to become worm-like. The skin is not solid, and is muscular. Around the mouth are situated the ten branched gills, while the feet are arranged in five rows along the body.

The trepang or beche-le-mer (*Holothuria edulis*) is collected in the Moluccas and Australian seas, and when dried is sold for soups in Chinese markets. Our native commonest species is *Pentacta frondosa* (Fig. 48).

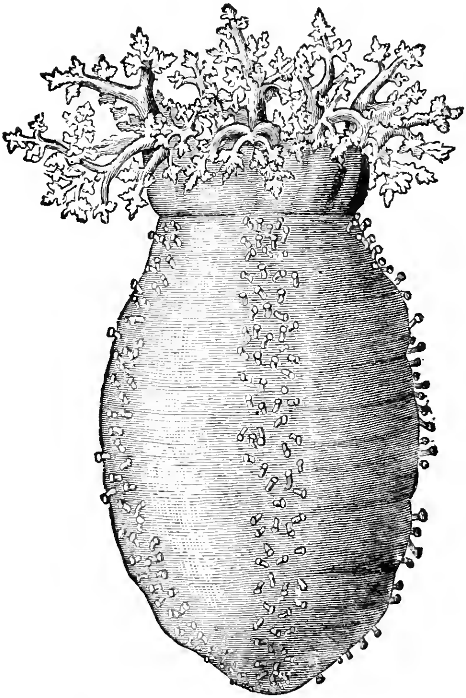


FIG. 48.—Common Sea-cucumber, with the gills nearly expanded. After Emerton.

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CHAPTER V.

Branch V.—Vermes (*Worms*).

General Characters of Worms.—In order to obtain an idea of worms in general the student may dig up in the garden or fields a common earth-worm, and then place it on the table or desk in a flat dish and watch its movements

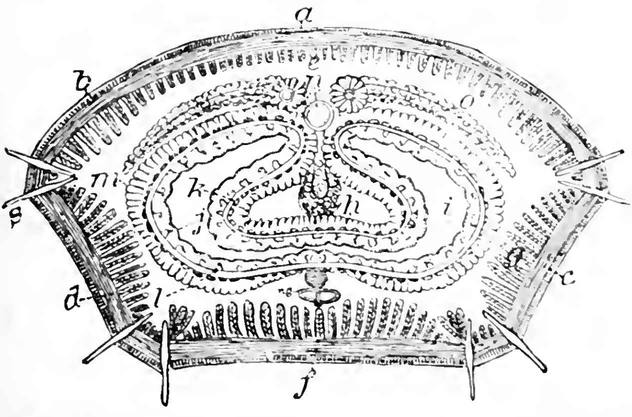

Fig. 49.—Transverse section through the body of the earth-worm (*Lumbricus terrestris*), near the middle of the intestine. *a*, cuticle; *b*, hypodermis; *c*, circular layer of muscles; *d*, layer of longitudinal muscles; *e*, dorsal band; *f*, ventral band; *g*, lateral bands; *h*, typhlosole; *i*, cavity of intestine; *j*, epithelium of intestine; *k*, layer of circular-muscular fibres around intestine; *l*, layer of longitudinal muscular fibres around intestine; *m*, green layer on outer surface of intestine; *n*, heart; *o*, liver; *ng*, nervous ganglion. After Claparède.

and appearance. The body will be seen to be formed of numerous joints or segments; these are due to infoldings of the muscular skin at regular intervals. Though both ends of the long, slender, cylindrical body are much

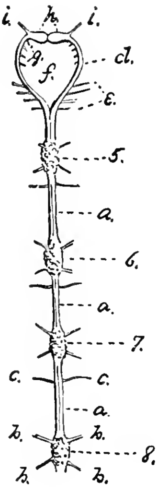

FIG 50.—"Brain" and part of the nervous or ganglionated cord of the earth-worm. *h*, brain, or first pair of ganglia; *g*, nerves to pharynx; *d*, œsophageal collar; *f*, space occupied by the pharynx; 5–8, the ganglia of the 5th to 8th segments respectively; *i*, nerves to first segment; nerve-threads or commissures. From Brooks, after Lankester.

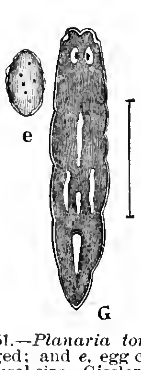

FIG. 51.—*Planaria torva*, enlarged; and *e*, egg capsule, natural size. Gissler del.

alike, the observer will soon be able to distinguish the head-end from the tail-end; he will also notice that both sides of the body repeat each other, and that there is an upper (dorsal) and lower (ventral) side, the worm lying on the latter side. The student will now be able to understand the following short definition of the branch of worms, to which there are some exceptions, which need not, however, be here mentioned. A typical worm is bilateral, with a well-marked dorsal and ventral side and a head-end and tail-end, with the body divided into segments.

By dissecting the body and tracing with needles the internal anatomy, and also by cross-sections of the body, the following relations of the most important internal organs will be observed. The digestive tract (*i*) is a slender tube lying free in the body-cavity, and extending from the mouth to the vent. Above it lies a long delicate, pulsating tube called the dorsal vessel or heart. The brain is small, and is situated in the upper part of the head, while behind the throat on the floor of the body lies the main nervous system, a double white cord with swellings called *ganglia* (Fig. 50), one for nearly each segment. A worm may or may not have eyes: some kinds of worms have them scattered all over the body; others have eyes both in the head and tail; many worms have ears. All worms grow from eggs, and many have a free swimming embryo entirely unlike the parent worm, thus passing through a "metamorphosis."

Classes of Vermes.

1. Body flat, often not segmented; no body-cavity . *Platyhelminthes.*
2. Body round, thread like; a body-cavity .... *Nematelminthes.*
3. Body microscopic, moving by two ciliated flaps. . *Rotatoria.*
4. Body minute, in a solid cell.................... *Polyzoa.*
5. Shell-worms, attached by a stalk, with two arms. . *Brachiopoda.*
6. Body rounded, or ribbon-like, with a proboscis.. . *Nemertina.*
7. Body jointed, with feelers, eyes, and gills .... *Annulata.*

Class I.—Platyhelminthes (*Flat-worms, Fluke-worms, Tape-worms, etc.*).

General Characters of Flat-worms.—The commonest example of this class is a small dark flat-worm which may be found in any pond on the under side of sticks or stones. This flat-worm is called *Planaria torva* (Fig. 51). It is about 7 mm. (¼ in.) in length, oblong, flat, with two black eye-spots, each with an oblong whitish space in front. Its body is covered with microscopic hairs (cilia), enabling it to move easily in the water. These worms have a rudimentary brain, from which pass backwards two slender nervous-threads, which do not have nervous swellings, as in the earth-worm. The digestive canal is also much branched. Besides these organs all the worms of this class have a so-called water-vascular system, somewhat like that of Echinoderms. These systems consist of two main tubes which branch throughout the body. Many if not most Planarians or free flat-worms have nettling organs somewhat like the lasso-cells of jelly-fishes, except that the rods are short and stiff, and are not known to be barbed.

Many flat-worms live as parasites in the bodies of other animals. They differ from ordinary Planarians in not being ciliated, while there is a large sucker on the under side of the body. These are called fluke-worms. *Fasciola hepatica* (Fig. 52) lives in the liver of the sheep, causing the disease known as "rot." It is most abundant in the spring, several hundred occurring in the liver of a single sheep. At this time it passes into the intestine, and thence is carried out with the excrement. The eggs or flukes in many cases drop into pools, ditches, or ponds; here the ciliated young is liberated, and soon the ciliæ are absorbed. when it becomes inert, and probably soon afterward enters the body of a pond snail (*Limnæus*), where it transforms into a large sac, and develops new larvæ in its interior. This sac-like larva is called a "nurse," or, when more highly developed, a "*redia*." The progeny of the *redia* is termed a "cercaria." The cercariæ are tadpole-like, and are restless, migrating from the bodies of their snail-host, and have been known in a few instances to penetrate the skin of human beings. They are probably more usually swallowed by sheep and cattle while drinking or grazing, when snail-shells may be accidentally swallowed. From the digestive canal of sheep, etc., the *cercaria* penetrates into the liver, where it probably loses its tail and becomes encysted, after many weeks or even months becoming a mature fluke-worm. From the liver it passes out through the liver-ducts into the intestine, and is finally expelled, thus completing its cycle of life.

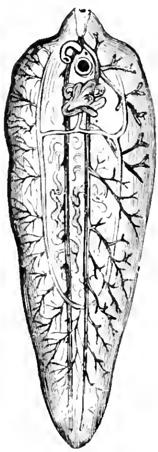

FIG. 52.—*Fasciola hepatica*, enlarged. *a*, branched intestine.

The tape-worms represent the order of *Cestodes*. They are large parasitic worms, with no mouth or digestive tract; the joints are very numerous, sometimes over a thousand in number.

The common human tape-worm, *Tænia solium*, varies from ten to thirty feet in length; there are upward of eight hundred joints in a worm ten feet long. The head ends in a proboscis armed with a double crown of hooks; the first proglottis or sexually mature segment begins at the 450th. While in some persons the presence of a tape-worm is simply an annoyance, in nervous and irritable persons it causes restlessness, undue anxiety, and various dyspeptic symptoms. Among the preventive remedies against tape-worms is the disuse of raw or underdone pork, and "measly" pork—*i.e.*, the flesh of swine containing the little bladder-like vesicles. Cysticerci, or young tape-worms, can be readily distinguished, but when thoroughly cooked are harmless, as the temperature of boiling water is sufficient to kill them. As a matter of course, in the use of drugs to expel a tape-worm they should be pushed so as to carry off the entire animal, as new segments grow out from near the head as rapidly as the joints are detached.

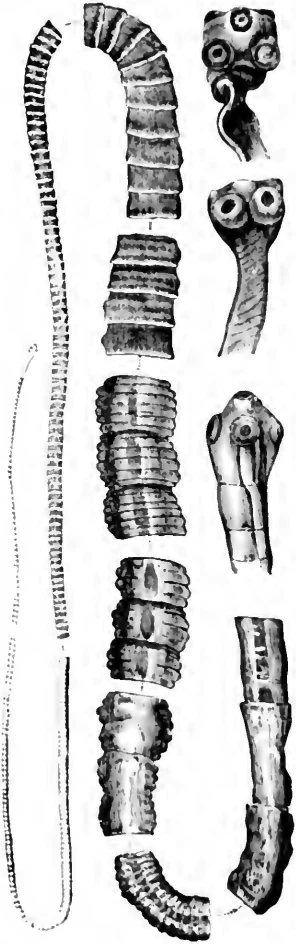

Fig. 53.—*Tænia solium.* Natural size, with the head magnified. Strobila stage.

The history of the human tape-worm, *Tænia solium* (Fig. 53), is as follows: The eggs eaten by the hog are developed in its body into the larval tape-worm (called in this species *Cysticercus cellulosæ*, Fig. 54). The head with its suckers is formed, and the body becomes flask-shaped; the Cysticerci then bury themselves in the liver or the flesh of pork, and are transferred living in uncooked pork to the intestines of man. The body now elongates and new joints arise behind the head until the form of the tape-worm is attained, as in Fig. 53.

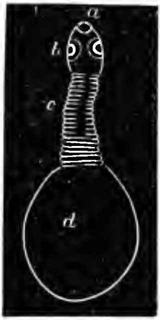

FIG. 54.—*Cysticercus*, or larval Tape-worm.

The hinder joints then become filled with eggs and break off, becoming independent joints comparable with the "parent-nurses" of the Cercarias, except that they are not contained in the body of the Tænia (as in the Cercaria), but are set free. The independent joint is called a "proglottis." It escapes from the alimentary tract of its human host, and the eggs set free, in and about privies, are swallowed by that unclean animal, the pig, and the cycle of generations begins anew.*

CLASS II.—NEMATELMINTHES (*Round- or Thread-worms*).

General Characters of Round-worms.—In these worms the body is round and thread-like, not being jointed. Many are parasitic: such are the Ascarids.

The round-worm most dangerous to human life is the *Trichina spiralis* (Fig. 55). It is very minute, the female being 3mm. in length, and the male worm half as long. The female is capable of producing a thousand young. The eggs are eaten by rats, dead rats are sometimes devoured by pigs, and pork thus infested when eaten by man, either raw or partly cooked, often causes the death of their human host.

The hair-worms (*Gordius aquaticus*, Fig. 56) resemble a piece of a horse's hair, and are so-called because they are

* See Van Beneden's Animal Parasites and Messmates, 1876.

popularly supposed to be "a horse-hair come to life." They occur tied up in a "Gordian knot" at the bottom of pools.

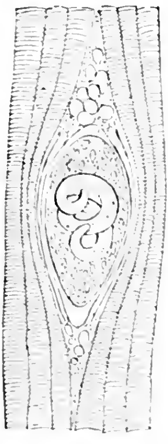

FIG. 55.—Trichina encysted in human muscle. Greatly magnified.

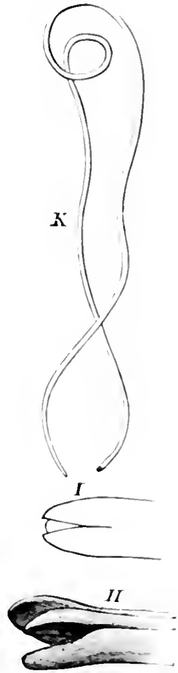

FIG 56.—The Hair-worm. *K* natural size; *I*, end of body of *G. aquaticus;* *H*, G. varius. Much enlarged.

FIG. 57.—*Rotifer vulgaris* c, ciliated flaps or wheels; *e*, mastax; *g*, digestive canal; *k*, eggs. Highly magnified.

They live as parasites in the bodies of grasshoppers, crickets, beetles, etc.

CLASS III.—ROTATORIA (*Rotifers*).

General Characters of Rotifers.—The Rotifers, or wheel-animalcules, are abundant in standing water, in damp moss, etc., and in the ocean, and are so transparent that their internal organs can readily be seen through the skin, while they are so minute, being from one fortieth to three hundredths of an inch in length ($\frac{5}{8}$ to $\frac{3}{4}$ mm.), that high powers of the microscope are needed in studying them. They are of special interest from the fact that after being dried for months to such a degree that little if any moisture is left in the body, they may be revived and become active. Professor Owen has observed the revivification of a Rotifer after having been kept for four years in dry sand.

Their body is often broad and flat, divided into a few segments of unequal size. They perform their rapid movements by means of two ciliated flaps, one on each side of the head, and which in motion resemble wheels, whence their name, wheel-animalcules. By means of the rotatory movements of the hairs on the edges of the flaps the microscopic Rotifer is whirled rapidly around.*

Class IV.—Polyzoa (*Moss Animals*).

General Characters of the Polyzoans.—The *Polyzoa*, though not usually met with in fresh water, are among

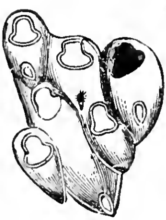

Fig. 58.—Cells of Sea-mat, enlarged.

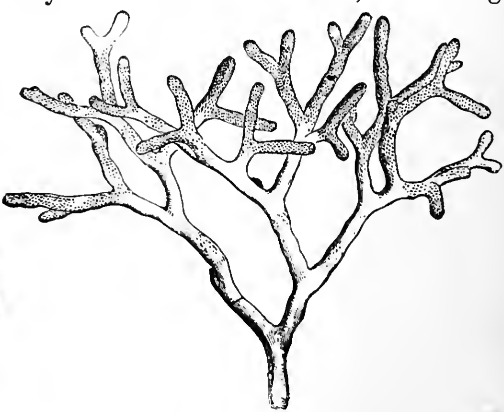

Fig. 59.—Branching marine Polyzoon. (Natural size.)

* See the works of Hudson, Gosse, Salensky, Hyatt, etc.

the commonest objects of the sea-shore. They are minute, almost microscopic creatures, social, growing in communities of cells, forming patches on sea-weeds and stones (Fig. 58, *Membranipora solida*). Certain deep-water species grow in coral-like forms (Fig. 59, *Myriozoum subgracile*), while the chitinous or horny *Polyzoa* are often mistaken for sea-weeds on the one hand, and Sertularian Hydroids on the other.

The animals inhabiting the microscopic cells are worm-like creatures (Fig. 60), with the digestive canal bent on itself and ending near the mouth, the latter surrounded, as in the larger fresh-water species (Fig. 60, *br*), with a horseshoe-shaped crown, or in the smaller marine forms a circle of slender ciliated tentacles. The fresh-water forms (*Plumatella*, etc.) secrete no solid shell, and are either moss-like, or form large rounded masses of a jelly-like substance.*

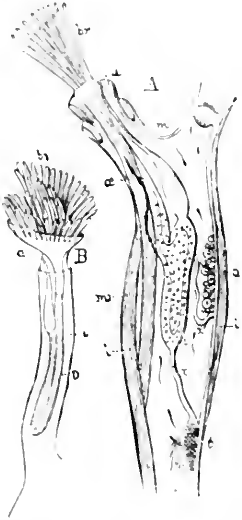

FIG. 60. Organization of a Polyzoon. *A*, *Paludicella Ehrenbergii*. *B*, *Plumatella fruticosa*. *br*, tentacular branchiæ of lophophore; *o*, oesophagus; *e*, stomach; *r*, intestine; *a*, anus; *i*, cell; *x*, posterior, *x*[1], anterior cord, at the insertion of which into the body the generative products are developed; *t*, testes; *o*, ovary; *m*, retractor muscles of the anterior portion of the cell; *mr*, principal retractor muscle.

CLASS V.—BRACHIOPODA (*Lamp Shells*).

General Characters of Brachiopods.—This group is named *Brachiopoda*, from the feet-like arms, fringed with tentacles, coiled up within the shell, and which correspond to the horseshoe-shaped crown of the *Polyzoa* and the crown of tentacles of the Sabella-like worms. From the fact that the animal secretes a true bivalved, solid shell, though it is usually inequivalve, *i.e.*, the valves of different sizes, the

* See the works of Allman, Hinks, Smitt, Salensky, Sars, etc.

Brachiopoda were generally, and still are by some authors, considered to be mollusks, though aberrant in type. The shell of our common northern species, *Terebratulina septentrionalis* (Fig. 61), which lives attached to rocks in from ten to fifty or more fathoms north of Cape Cod, is in shape somewhat like an ancient Roman lamp, the upper and larger valve being perforated at the base for the passage through it of a peduncle by which the animal is attached to rocks. The shell is secreted by the skin, and is composed of carbonate (*Terebratulina*) or largely (*Lingula*, Fig. 62) of phosphate of lime. It is really the thickened

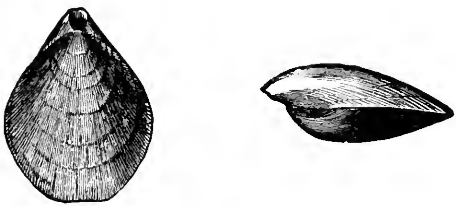

FIG. 61.—Terebratulina or lamp-shell. Upper, and side view, natural size. From Emerton, after Morse.

skin of the animal, the so called mantle being the inner portion of the skin.

The Brachiopods may be briefly described as shelled worms, with a limestone or partly chitinous, inequivalve, hinged or unhinged shell, enclosing the worm-like animal; with two spirally coiled arms provided with dense ciliated tentacles, and capable of reaching to or beyond the edge of the gaping shell; the alimentary canal has the mouth opening between the arms; there is an œsophagus, a stomach with a liver-mass on each side, and a short intestine ending in a blind sac. The nervous system consists of a ganglion above and beneath the œsophagus, and two lateral ventral widely separated threads. There are no eyes in the adult, but they are present in the young; auditory sacs are present in Lingula. There is no circulatory system. The germ passes through a morula and gastrula stage, becoming a segmented ciliated larva like that of the true worms, which after swimming about finally becomes fixed by a stalk to rocks.

While in their development the Brachiopods recall the larvæ of the true worms, they resemble the adult worms in the general arrangement of the arms and viscera, though they lack the highly developed nervous system of the Annelids, as well as a vascular system, while the body is not jointed. On the other hand they are closely related to the *Polyzoa*, and it seems probable that the Brachiopods and

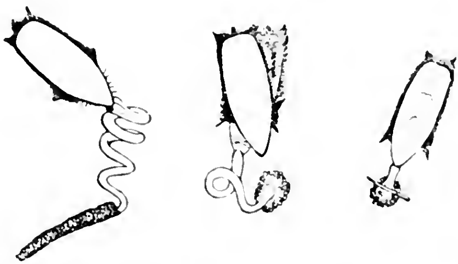

FIG. 62.—*Lingula pyramidata* with its sand-tube; natural size.

Polyzoa were derived from common low vermian ancestors, while the true Annelids probably sprang independently from a higher ancestry. They are also a generalized type, having some molluscan features, such as a bivalved shell, though having nothing homologous with the foot, the shell-gland or odontophore of mollusks.

The class of Brachiopods is a very ancient one, nearly 2000 species of fossil Brachiopods being known. One living species of Lingula (Fig. 62) differs but slightly from the most ancient fossil species. It lives buried in the sand, where it forms a tube of sand around the stalk, just below low-water mark, extending from Chesapeake Bay to Florida.

LITERATURE.

A. Hancock. On the Organization of the Brachiopoda. Phil. Trans. 1858.

E. S. Morse. On the Systematic Position of the Brachiopoda. Proc. Boston Soc. Nat. Hist., xv. 1873.

With the essays of Brooks, Lacaze-Duthiers, Kowalevsky, Dall, etc.

Class VI.—Nemertina (*Nemertean Worms*).

General Characters of Nemerteans.—The Nemertean worms occur abundantly under stones, etc., between tide-marks and below low-water mark; they are of various colors, dull red, dull green and yellowish, and are distinguished by the soft, very extensile, more or less flattened, long and slender body, which is soft and ciliated over the surface, the skin being thick and glandular.

The mouth forms a small slit on the ventral surface immediately behind the aperture for the exit of a large proboscis. The œsophagus leads to a large digestive tract, which often has short lateral pouches or cœca.

The nervous system is quite simple, consisting of two ganglia in the head united by a double commissure; from each ganglion a thread composed of nerve-fibres and ganglion-cells passes back to the end of the body.

Class VII.—Annulata (*Leeches, Earth-worms, and Sea-worms*).*

General Characters of the Annulates.—This group, represented by the leeches, earth-worms, and nereids or bristled sea-worms, tops the series of the classes of worms. With their regularly segmented bodies, their eyes and ears and complicated appendages, they stand nearer the Crustacea and Insects than any other class of invertebrate animals, their internal anatomy on the whole being nearly or quite as complicated.

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* Class *Enteropneusta* and Class *Gephyrea* are small groups of worms, which are described in the author's larger Zoology. They may be omitted in an elementary course for want of space.

In the leech, which is the type of the first and lower order, the body is somewhat flattened and divided into numerous short, indistinctly marked segments, not bearing any bristles or appendages. The head is small, with no appendages, bearing five pairs of simple eyes, while each end of the body terminates in a sucker. The mouth is armed internally with three teeth arranged in a triradial manner (Fig. 65, *C*), so that the wound made in the flesh of persons to whom the leech is applied consists of three short, deep gashes radiating from a common centre. Our common pond leech (*Macrobdella decora*, Figs. 64, 65) is of a

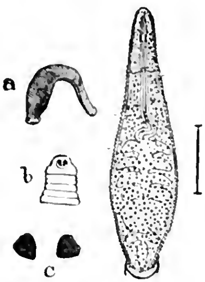

Fig. 63.—Common fish-leech. *a*, natural size; *b*, head with two eyes; *c*, teeth. Gissler, del.

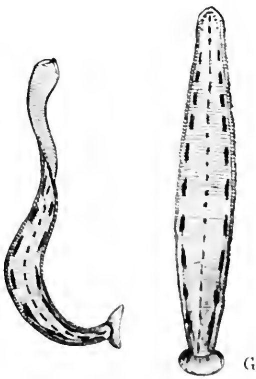

Fig. 64.—Young *Macrobdella decora*. Body unnaturally flattened. Gissler, del.

rich deep olive color above, and orange red on the under side. It is four inches in length. Another common pond leech is *Nephelis*, of which we have several species.

The eggs of leeches are laid in sacs, or, as in *Clepsine* (Fig. 63), the fish-leech, are covered with a transparent fluid substance, which hardens and envelops the eggs. The *Clepsine* remains over the eggs to protect them until they hatch; and the young fix themselves to the under side of the parent, and are thus borne about until they are fully developed and able to provide for themselves.

The common earth-worm (Fig. 66) is cylindrical and many-jointed. The small mouth opens on the under side of the first segment. The earth-worm is able to climb perpendicularly up boards or the sides of buildings by minute,

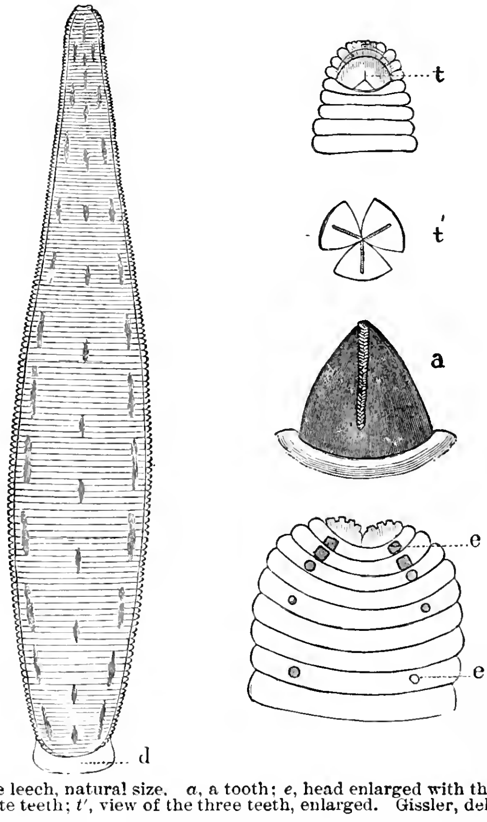

FIG. 65.—Large leech, natural size. *a*, a tooth; *e*, head enlarged with the eyes; *t*, triradiate teeth; *t'*, view of the three teeth, enlarged. Gissler, del.

short, curved bristles, which are deeply inserted in the muscular walls of the body, and arranged in two double rows along each side of the body (Fig. 49*s*). In burrowing it thrusts the pharynx into the end of the head, causing it to swell out, and thus push the earth away on all sides, while it also swallows the dirt, which passes through the digestive canal. In this way it may descend from three to eight feet in the soil.

While earth-worms are in the main beneficial, from their habit of boring in the soil of gardens and ploughed lands, bringing the subsoil to the surface and allowing the air to get to the roots of plants, they occasionally injure young seedling cabbage, lettuce, beets, etc., drawing them during the night into their holes, or uprooting them.*

Earth-worms lay their eggs in June and July, at night.

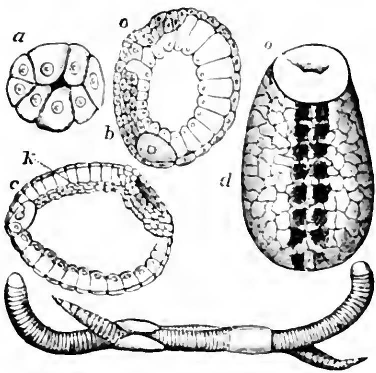

Fig. 66.—Earth-worms, nat. size. *a*, embryo (blastula) soon after segmentation of the yolk; *b*, embryo further advanced; *o*, mouth; *c*, embryo still older; *k*, primitive streak; *d*, neurula; *o*, its mouth.

The eggs of the European *Lumbricus rubellus* are laid in dung, a single egg in a capsule; *L. agricola* lays numerous egg-capsules, each containing sometimes as many as fifty eggs, though only three or four live to develop. The development of the earth-worm is like that of the leech, the germ passing though a number of stages, the worm, when hatching, resembling the parent, except that the body is shorter and with a much less number of segments.

The sea-worms have larger, more distinct bristles, as in *Clymenella* (Fig. 67), which lives in tubes in soft mud.

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*Darwin's Formation of vegetable mould through the action of worms.

Our commonest sea-worm, sometimes called the "clam-worm" is *Nereis virens* (Fig. 68). It lives between tide-marks in holes in the mud, and can be readily obtained. The body, after the head, eyes, tentacles, and bristle-bear-

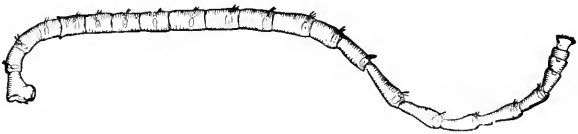


Fig. 67.—*Clymenella torquata*, natural size.

ing feet have been carefully studied, can be opened along the back by a pair of fine scissors and the dorsal and ventral red blood-vessels with their connecting branches observed, as well as the alimentary canal and the nervous system.

This worm is very voracious, thrusting out its pharynx

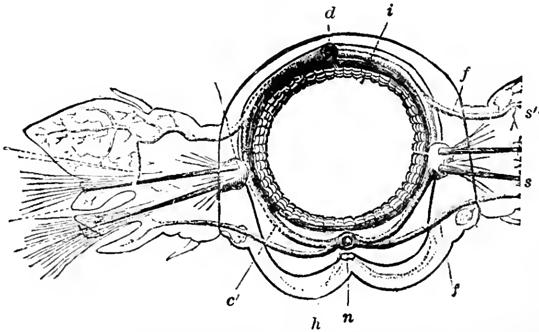


Fig. 68.—Transverse section through the body of a Nereis. *d*, dorsal vessel or heart; *c'*, circular blood-vessel; *h*, ventral vessel; *n*, nervous cord or ganglia; *f*, artery to swimming foot *s''*; *i*, intestine; *s*, setæ or bristles. After Turnbull, from Emerton.

and seizing its prey with its two large pharyngeal teeth. It secretes a viscid fluid lining its hole, up which it moves, pushing itself along by its bristles. At night it leaves its hole, swimming on the surface of the water.

The body consists of from one hundred to two hundred segments. The head consists of two segments, the first

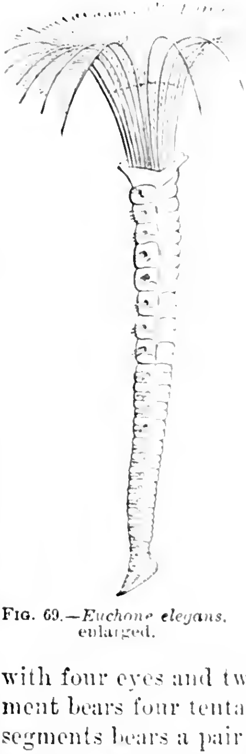


FIG. 69.—*Euchone elegans*, enlarged.

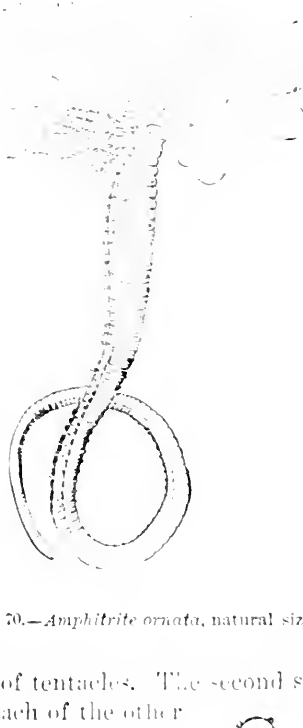


FIG. 70.—*Amphitrite ornata*, natural size.

with four eyes and two pairs of tentacles. The second segment bears four tentacles. Each of the other segments bears a pair of paddle-like appendages, which may be best studied by examining one of the middle segments (Fig. 68).

FIG. 71.—Ciliated larva of a sea-worm (*Phyllodoce*).

In certain kinds, as *Euchone* (Fig. 69), the gills form a beautiful feathery crown on the head; while in *Amphitrite* (Fig. 70) the tentacles are very numerous, and the bushy red gills grow out by their side. Some sea-worms are beautifully phosphorescent. The young of all sea-worms (Fig. 71) are ciliated, and swim on the surface of the sea.*

* See Verrill's works in U. S. Fish Commission Reports, etc.

CHAPTER VI.

Branch VI.—Mollusca.

General Characters of Mollusks.—In these animals the body is soft, and usually protected by a shell which is secreted by the skin or " mantle," but the body is not segmented as in worms. They have a so-called "foot" or creeping disk, and the mouth is often armed with a ribbon-like band provided with sharp teeth called the "lingual ribbon." The heart is more like that of vertebrates than any of the foregoing animals, consisting of a ventricle and either one or two auricles. The nervous system is very simple, consisting of three pairs of nerve-centres or ganglia and thread-like nerves. There are about 20,000 living and 19,000 extinct species of mollusks known.

Classes of Mollusca.

1. Shell bivalved.................. *Lamellibranchiata.*
2. Shell univalve.... .... *Cephalophora.*
2. Usually no shell, 8–10 arms. ..... *Cephalopoda.*

Class I.—Lamellibranchiata (*Acephala, Bivalves, Clam, Oyster, etc.*).

General Characters of Lamellibranchs.—The headless mollusks are represented by the oyster, clam, mussel, quohog, scallop, etc. By a study of the common clam (*Mya arenaria*) one can obtain a fair idea of the anatomy of the entire class.

The clam is entirely protected by a pair of solid limestone shells, connected by a hinge, consisting of a large tooth (in most bivalves there are three teeth) and ligament (Fig. 72, C L). The shells are

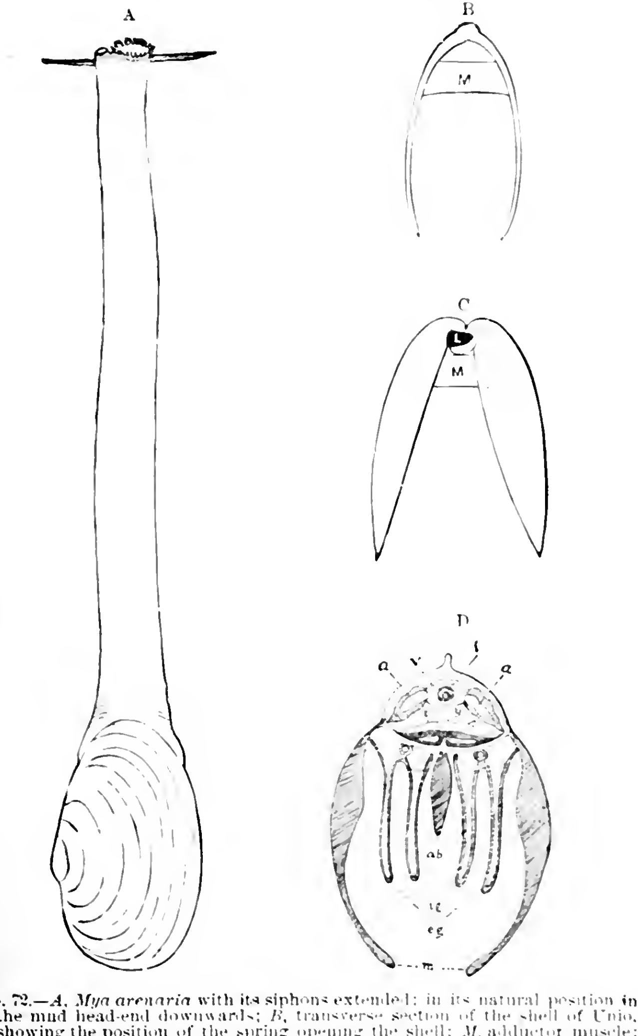


FIG. 72.—*A*, *Mya arenaria* with its siphons extended; in its natural position in the mud head-end downwards; *B*, transverse section of the shell of Unio, showing the position of the spring opening the shell; *M*, adductor muscle; the ligament represented by the dark mass; *C*, section of Mya, showing the position of the spring to open the shell; *L*, ligament; *D*, transverse section of Unio (after Brooks); *ab*, visceral mass; *a*, auricles; *v*, ventricle; *i*, intestine; *t*, glandular part of kidney; *z*, non-glandular part of kidney; *y*, sinus venosus; *ig*, inner, *eg*, outer, gills; *m*, mantle.

equivalve, or with both valves alike, but not equilateral, one end (the anterior) being distinguishable from the other or posterior, the clam burrowing into the mud by the anterior end, that containing the mouth of the mollusk. The hinge is situated directly over the heart, and is therefore dorsal or hæmal. On the interior of the shells are the two round "muscular impressions" made by the two adductor muscles and the "pallial impression," parallel to the edge of the shell, made by the thickened edge of the mantle. On carefully opening the shell, by dividing the two adductor muscles, and laying the animal on one side in a dissecting trough filled with water, and removing the upper valve, the mantle or body-walls will be disclosed; the edge is much thickened, while within, the mantle where it covers the elliptical rounded body is very thin. The so-called black head, or siphon, is divided by a partition into two tubes, the upper, or

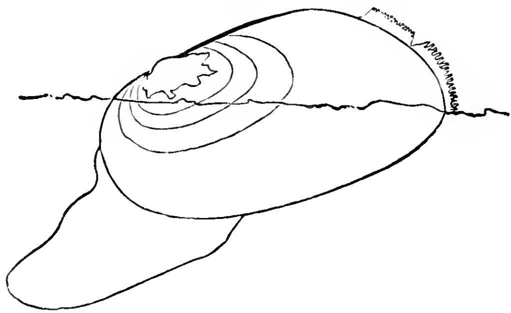


FIG. 73.—*Unio complanatus*, fresh-water mussel, partly buried in the sand, the siphonal openings above the level of the river-bottom.

that on the hinge or dorsal side, being excurrent; the lower and larger being incurrent—a current of sea-water laden with minute forms of life passing into it. Each orifice is surrounded with a circle of short tentacles. This siphon protrudes through a slit in the mantle-edge, and is very extensible, as seen in Fig. 72, *A*; it is extended, when the clam is undisturbed, from near the bottom of its hole to the level of the sea-bottom. In the fresh-water mussel (*Unio*, Fig. 73) the two siphonal openings are above the level of the sandy bottom of the water, when the mussel is ploughing its way through the sand with its tongue-shaped foot, which is a muscular organ attached to the body mass. In the foot is an orifice for the passage in and out of water, but the spurting of water from the clam's hole, observed in walking over the flats, is the stream thus ejected from the siphon. The inflowing currents of water pass from the inner end of the muscular siphon below the lenticular body-mass to the mouth, which is situated at the anterior end of the shell, opposite the siphon The opening is simple, unarmed, without lips, and often difficult to detect. On each side of the mouth is a pair of flat, narrow-pointed appendages called palpi. The digestive canal passes through a dark rounded mass, mostly consisting of the liver, covered externally by the ovarian masses. The mouth has no teeth, and the œsophagus leads to a tubular stomach and intestine, the latter loosely coiled several times and then passing straight backwards along the dorsal side under the hinge and directly through the ventricle of the heart, ending posteriorly opposite the excurrent division of the siphon. Through the body passes a curious slender cartilaginous rod, whose use is unknown, unless it be to support the voluminous viscera. The gills or branchiæ are four large, broad, leaf-like folds of the mantle, two on a side, hang-

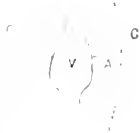


FIG 74.—Heart of the clam. *V*, ventricle; *A*, auricles; *G*, base of gills.

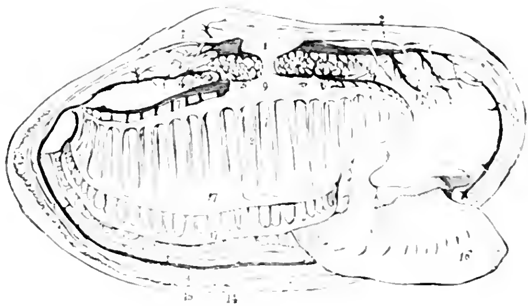


FIG. 75.—Circulatory system of *Anodonta*, a fresh-water mussel. 1, ventricle; 2, arterial system; 14 and 15, veins which follow the border of the mantle. The veins lead the blood in part directly towards the organ 4, which is the kidney or "organ of Bojanus," and in part to the venus sinus of the upper surface of this organ; 5, veins which carry back the blood from the gills, the rest going to the sinus, 6, where arise the branchial arteries; 7, 8, the branchial veins, and 9, the gill; 16, the foot.

ing down and covering each side of the body (Fig. 72, D, a). The heart (Fig. 74) is contained in a delicate sac, called the *pericardium*, and is situated immediately under the hinge; it consists of a ventricle and two auricles; the former is easily recognized by the passage through it of the intestine (Fig. 72, D, v), usually colored dark, and by its pulsations. The two wing-like auricles are broad, somewhat trapezoidal in form. Just behind the ventricle is the so-called "aortic bulb." The arterial system is quite complicated, as is the system of venous sinuses, which can be best studied in carefully injected specimens. At the base of the gills, however,

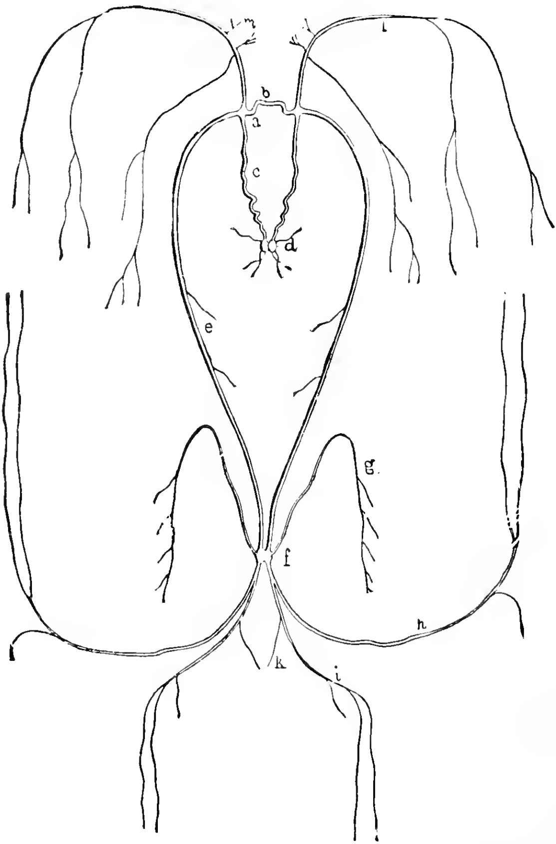


FIG. 76.—Nervous system of the clam, natural size. *a*, œsophageal ganglion; *b*, commissure anterior to the mouth; *c*, pedal commissure; *d*, pedal ganglia; *e*, parieto-splanchnic commissures; *f*, parieto-splanchnic ganglia; *g*, branchial nerves; *h*, *l*, pallial nerves; *i*, siphonal nerves; *k*, anal nerves; *m*, nerves to the anterior adductor muscle.

is the pair of large collective branchial veins. The kidney, or "organ of Bojanus," is a large dusky glandular mass (Fig. 75, 4) lying below but next to the heart; one end is secretory, communicating with the pericardial cavity, while the other is excretory and opens into the cavity of the body.

The nervous system can be, with care and patience, worked out in the clam or fresh-water mussel. In the clam (*Mya arenaria*, Fig. 76) it consists of three pairs of small ganglia, one above (the "brain") and one below the œsophagus (the pedal ganglia) connected by a commissure, thus forming an œsophageal ring; and at the middle of the mantle, near the base of the gills, is a third pair of ganglia (parieto-splanchnic), from which nerves are sent to the gills and to each division of the siphon. This last pair of ganglia can be usually found with ease, without dissection, especially after the clam has been hardened in alcohol. The ear of the clam is situated in the so-called foot; it bears the name of *otocyst*, and is connected with a

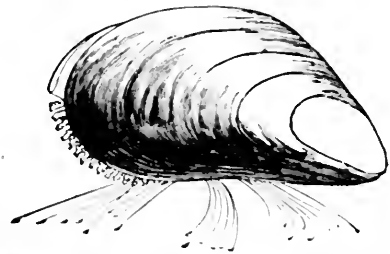


FIG. 77.—*Mytilus edulis*, common mussel, with its siphons expanded, and anchored by its byssus.

nerve sent off from the pedal ganglion. It is a little white body found by laying open the fleshy foot through the middle. Microscopic examination shows that it is a sac lined by an epithelium, resting on a thin nervous layer supported by an external coat of connective tissue. From the epithelium spring long hairs; the sac contains fluid and a large otolith. The structure of this otocyst may be considered typical for Invertebrates.

The ovaries or testes, as the sex of the clam may be, are bilaterally symmetrical, blended with the wall of the vi ceral or liver mass, and are yellowish. The openings for the exit of the eggs lie near the base of the foot.

In the oyster the two shells are unlike, the lower shell being usually larger than the upper. A single oyster may produce over a million young. In six hours after development begins, the ciliated germ swims about in the water.

When $\frac{3}{10}$ mm. ($\frac{1}{80}$ inch) in diameter it becomes fixed to a rock, and at the end of a year is capable of breeding. Oy-

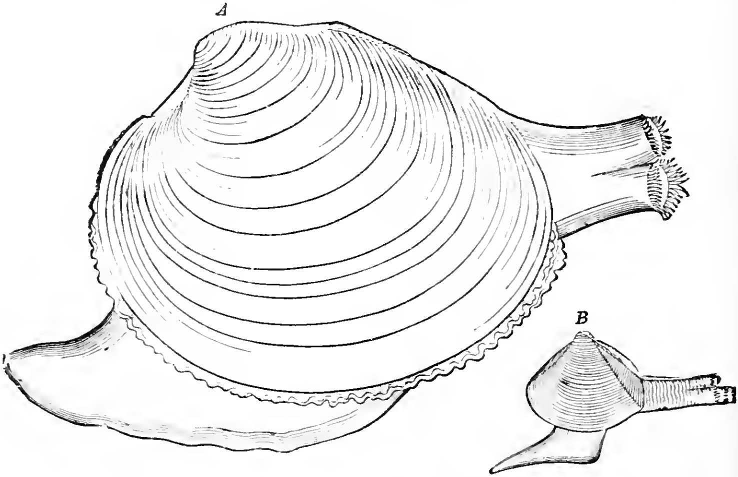


FIG. 78.—*A*, *Venus mercenaria*, quohog, natural size, with the foot and siphons; *B*, *Mactra* (*Mulinia*) *lateralis*, natural size.

sters get their full growth by the second or third year. They breed from July to September.

FIG. 79.—The Ship-worm, natural size. *t*, siphons; *p*, pallets; *c*, collar; *s*, shell; *f*, foot.

The mussel (Fig. 77) has a small foot, with a gland for secreting a bundle of threads, the *byssus*, by means of which it is anchored to the bottom. The foot in the quohog (Fig. 78, *A*, *Venus mercenaria*; 78, *B*, *Mulinia*) is large.

The ship-worm (Fig. 79) belongs to this class. The body is slender and worm-like. The shell is minute, the soft animal living in a burrow lined with limestone. This animal develops like other mollusks: the young (Fig. 80, *B*) having two equal shells inclosing the body, and swimming by its ciliated velum or sail (*v*). After the foot (Fig. 80, *f*) is well developed it seeks the piles of wharves and floating

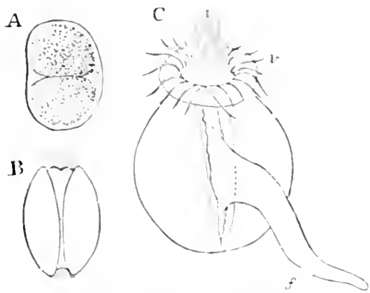


FIG. 80.—Development of the Ship-worm. *A*, egg, with the yolk once divided; *B*, the veliger enclosed by the bivalve shells; *C*, advanced veliger with the large foot (*f*) and velum (*v*).

wood, into which it bores and completes its metamorphosis. On the coast of New England the ship-worm lays eggs in May and probably through the summer.

CLASS II.—CEPHALOPHORA (*Whelks, Snails, etc.*).

General Characters of Cephalophores.—We now come to Mollusks with a head bearing eyes and tentacles; but the bilateral symmetry of the body, so well marked in the clam, etc., is now in part lost, the animal living in a spiral shell. Still the foot and head are alike on both sides of the body; while the foot forms a large creeping flat disk by which the snail glides over the surface of leaves, etc. Moreover, these mollusks have, besides two teeth, a "lingual ribbon." Familiar examples of the class are the sea-snails, the sea-slugs, and the genuine air-breathing snails and slugs.

In the shell-less or Nudibranch mollusks, such as the

FIG. 81.—*Æolis*, a Nudibranch; enlarged twice.

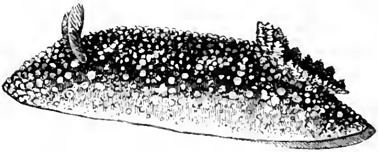


FIG. 82.—Doris; enlarged.

FIG. 83.—*Physa heterostropha*. Common pond-snail. After Morse.

Eolis and *Doris* and allied forms, the gills are arranged in bunches on the back, as seen in Fig. 81, *Æolis pilata*, a common species on the coast of New England. In Doris (Fig. 82) they are confined to a circle of pinnate gills on the hinder part of the back.

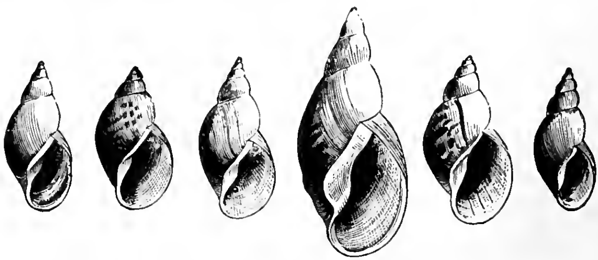


FIG. 84.—*Limnæus elodes*, a common pond-snail, showing its variations. After Morse.

The air-breathing mollusks (*Pulmonata*) are represented by the pond-snails, *Physa* (Fig. 83) and *Limnæus* (Fig. 84), and the land-snails and slugs. Fig. 85 represents a slug suspended by a slimy thread from a twig.

The common snail, *Helix albolabris*, is a type of the air-breathing mollusks. Fig. 86 represents this snail of natural size, in its shell. The opening to the lung is seen at *a*, and at *B* is represented the heart and lung of the garden slug (*Limax flavus*).

The eggs of the pond-snails are laid in transparent capsules attached to submerged leaves, etc. Those of *Physa heterostropha* are laid in the early spring, and three or four weeks later from fifty to sixty embryos with well-formed shells may be found in the capsule.

Fig. 85.—Slug; natural size.

The eggs of *Limnæus* are laid late in the spring in capsules containing one or two eggs, and surrounded by a mass of jelly.

Land-snails and slugs lay their eggs loose under damp leaves and stones, and development is direct, the young snail hatching in the form of the adult.

Various shells, such as *Marginella, Turbinella*, etc., are

Fig. 86.—*A*, common snail, natural size; *B*, the heart and lung.

strung in bracelets and armlets by savages. *Cypræa moneta*, the cowry (Fig. 87), is used for money, and other shells are worked into various shapes for wampum or aboriginal money. *Murex* and *Purpura* afford the Tyrian dye.

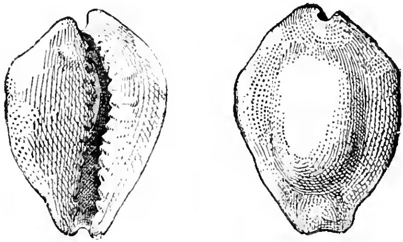


Fig. 87.—*Cyprœa moneta*, money cowry.

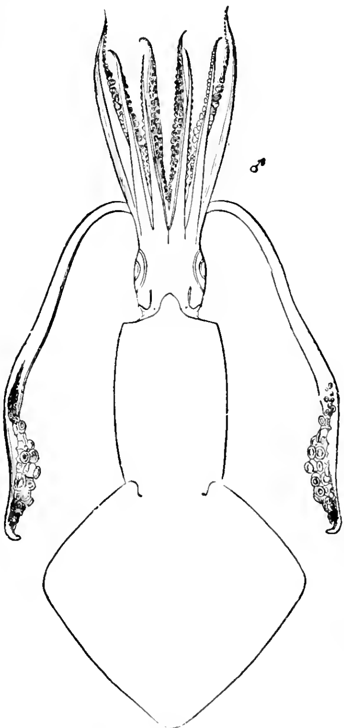


Fig. 88.—*Loligo pealii;* male. About one-third natural size.

Class III.—Cephalopoda (*Cuttle-fish, Squid*).

General Characters of Cephalopods.—In these mollusks (Fig. 88) the head in front of the eyes is divided into arms usually provided with suckers; the eyes are large, and nearly as perfect as in fishes. The brain is large, and with the other important nervous ganglia lodged in the head and protected by pieces of cartilage. The mouth-cavity (pharynx) is armed with two teeth like a parrot's beak, besides a lingual ribbon (Fig. 89). The body is supported by a horny "pen" (Fig. 90).

The Cephalopods are divided into two orders. The first order (*Tetrabranchiata*) have four gills within the mantle; such is the *Nautilus* (Fig. 91, *N. pompilius*). The second order, *Dibranchiata*, is so called from having but two gills. The Octopods (Fig. 92) have eight arms, and the squid or cuttle-fish have ten. The largest known squid is *Architeuthis princeps* (Fig. 93); the body of the specimen here figured measured nine

Fig. 89.—Part of lingual ribbon of *Loligo Hartingii;* much enlarged.

Fig. 90.—Pen of *Loligo pallida*, dorsal side; natural size.

and a half feet from the tip of the tail to the base of the arms, and was seven feet in circumference. The longer arms were thirty feet in length. Ordinary squids are about a foot long.

The paper nautilus (*Argonauta argo*) has a beautiful thin crumpled shell. It inhabits deep water from 70 to 100 miles off the coast of southern New England. The ani-

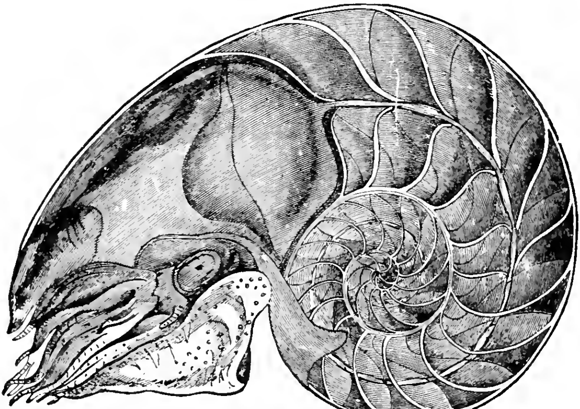


FIG. 91.—The Nautilus, with shell seen in section, showing the chambers

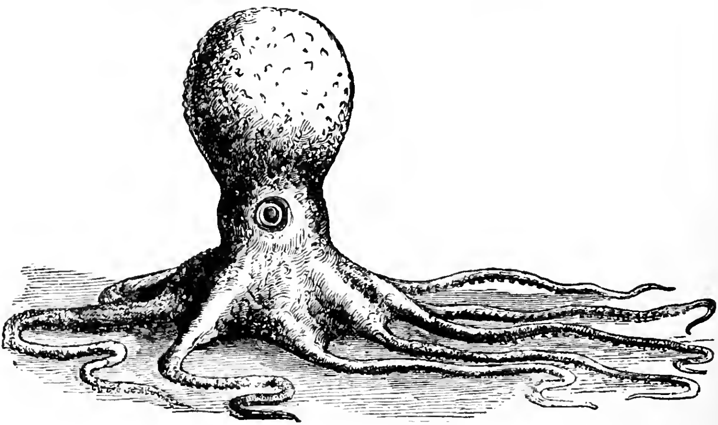


FIG. 92.—Octopus, from Brazil.

mal lives in the shell, but is not permanently attached to it, the shell not being chambered, like that of the Nautilus, The animal holds on to the sides of its shell by the so-called "sails" or broad thin ends of two of its arms, which secrete the shell.

Fig. 93.—Giant Squid, reduced in size. After Verrill. From Emerton

Literature.—Article *Mollusca*, by E. R. Lankester, in Encyclopædia Britannica. Woodward's Manual of the Mollusca, 1868.

CHAPTER VII.

Branch VII.—Arthropoda (*Crustaceans, Insects, etc.*).

General Characters of Arthropods.—To this group belong those segmented animals which have jointed appendages, *i.e.*, antennæ, jaws, maxillæ (or accessory jaws), palpi, and legs arranged in pairs, the two halves of the body thus being more plainly symmetrical than in the lower animals. The skin is usually hardened by the deposition of salts, mostly carbonate of lime, and of a peculiar organic substance called *chitine*. The segments or rings composing the body are usually limited in number, there being usually twenty in the Crustaceans and seventeen or eighteen in most insects, though in the Myriapods there may be as many as two hundred. The head is usually distinct from the body, with one (insects) or two (Crustacea) pairs of feelers (antennæ), from two to four pairs of biting mouth-parts or jaws, and two compound eyes (except in the spiders, etc.), besides simple eyes. Most Arthropods pass through a series of changes of form called a metamorphosis; the young of the butterfly being called a caterpillar or larva, the succeeding stage a pupa or chrysalis, and the mature stage the imago.

Classes of Arthropoda.

Class 1. A head-thorax and abdomen; two pairs of antennæ; breathing by external gills .... *Crustacea:* lobster, crab.

Class 2. Body with few or many segments; no antennæ, all the appendages like legs; with gills.... *Podostomata:* king crab, trilobites.

Class 3. Body worm-like, tracheate, with two antennæ; fleshy legs armed with claws............... *Malacopoda:* Peripatus.

Class 4. Body many-segmented, many-footed, tracheate; with a pair of antennæ................ *Myriapoda:* centipede.

Class 5. Body in two regions; no antennæ, four pairs of legs; tracheate. *Arachnida:* spider, scorpion.

Class 6. Body divided into a head, thorax, and abdomen; breathing by internal air tubes; with wings. *Insecta:* beetle, butterfly.

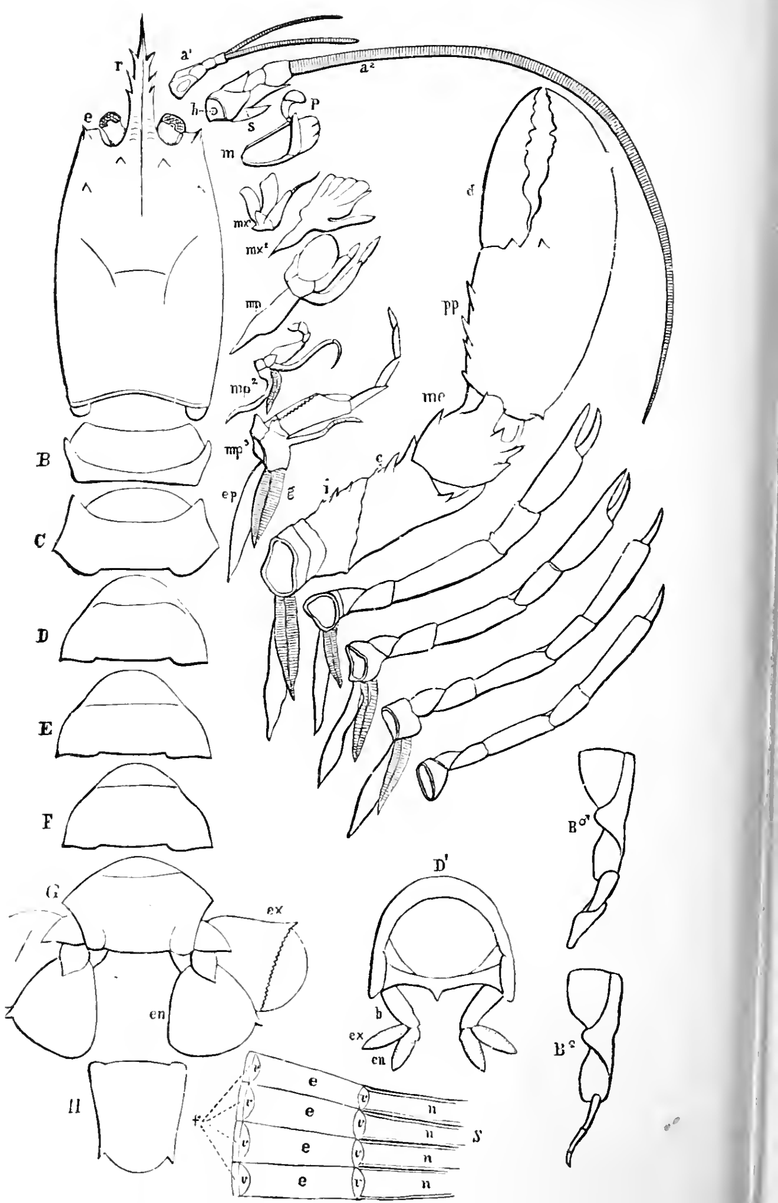
CLASS I.—CRUSTACEA (*Water-fleas, Shrimps, Lobsters, and Crabs*).

General Characters of Crustaceans.—The typical forms of this class are the craw-fish, lobster, and crab, which the student should carefully examine, as from them a general knowledge of the class, which varies greatly in form in the different orders, may be obtained. The following account of the lobster will serve quite as well for the craw-fish, which abounds in the rivers and streams of the Central and Western States.

The lobster's body consists of segments, six of which in the abdomen are seen to form a complete ring, bearing a pair of jointed appendages. The abdomen consists of seven segments. One of these segments (Fig. 94, *D*) should be separated from the others by the student, in order to observe the mode of insertion of the legs. Each segment bears but a single pair of appendages, and it is a general rule that in the Arthropods each segment bears but a single pair of appendages. The abdominal feet are called "swimmerets;" they are narrow, slender, divided at the end into two or three lobes or portions, and are used for swimming, as well as in the female for carrying the eggs. The first pair are slender in the female (Fig. 94, *B* ♀) and not divided, while in the male (Fig. 94, *B* ♂) they are much larger, and aid in reproduction. The sixth segment (Fig. 94, *G*) bears broad paddle-like appendages, while the seventh segment, forming the end of the body and called the "telson," bears no appendages. It represents the tergum alone of the segment. Turning now to the cephalothorax, we see that there are two pairs of antennæ, the smaller pair the most anterior; a pair of mandibles with a palpus, situated on each side of the mouth; two pairs of maxillæ or accessory jaws, which are flat, divided into lobes, and of unequal size; three pairs of foot-jaws (maxillipedes), which differ from the maxillæ in having gills like those in the five following pairs of legs.* There are thus

FIG. 95.—Mandible of the lobster, *Homarus americanus*: *pal*, palpus.

* The students can separate these limbs in a boiled lobster or cray-fish, and compare them with the cuts. He will find the exercise an interesting one.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thirteen pairs of cephalo thoracic appendages, indicating that there are thirteen corresponding segments; these, with the seven abdominal segments, indicate that there are twenty segments in a typical Crustacean. There is a pair of stalked movable compound eyes. The ears are situated in the smaller antennæ (Fig. 94, a'). In the second or larger antennæ are situated the openings of the ducts (Fig. 94, h) leading from the "green glands," while the external openings of the oviducts are situated, each on one of the third pair of thoracic feet.

It is impossible, except by counting the appendages themselves, to ascertain with certainty the number of segments in the cephalo-thorax, the dorsal portion of the segments being more or less obsolete, but the carapace, or shield of the head-thorax, may be se n, after close examination, to represent the second antennal and man-

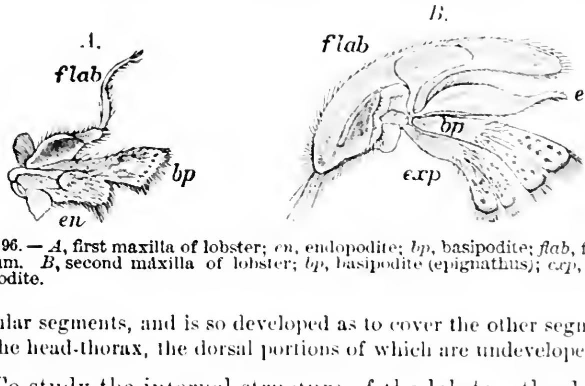

Fig. 96. — *A*, first maxilla of lobster; *en*, endopodite; *bp*, basipodite; *flab*, flabellum. *B*, second maxilla of lobster; *bp*, basipodite (epignathus); *exp*, coxopodite.

dibular segments, and is so developed as to cover the other segments of the head-thorax, the dorsal portions of which are undeveloped.

To study the internal structure of the lobster, the dorsal surface of the carapace and of each abdominal segment should be removed; in so doing the soft inner layer of the integument is disclosed; it is usually filled with red pigment cells. The heart lies under the middle of the carapace; it is an irregular hexagonal mass surrounded by a thin membrane (pericardium) with six valvular openings

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Fig. 94.—*A*, carapace; *e*, eyes; *r*, rostrum; a^1, first pair of antennæ; a^2, second pair; *h*, outlet of green gland; *m*, mandible, and *p*, its palpus; *mx*, first maxilla; m^2, second maxilla; *mp*, first maxillipede; mp^2, second maxillipede; mp^3, third maxillipede; with *ep*, epipodite, and *g*, gill; *i–d*, first leg; *B–G*, six abdominal segments; *H*, telson; *B* , first pair abdominal legs of male; *B* , of female; *D'*, section of abdomen, with *en*, endopodite; *ex*, exopodite; *b*, basipodite; *S*, section of eye; *f*, cornea; *c*, cones; *e*, rod; *n*, branches of main optic nerve.

for the ingress of the venous blood. The colorless blood is pumped by the heart backwards and forwards through three anterior arteries, one median and two lateral, the median artery passing towards the head over the large stomach, and the two lateral, or hepatic arteries, passing to the liver and stomach. From the posterior angle of the heart arise two arteries; the upper, a large median artery (the superior abdominal), passes along the back to the erd of the abdon.en, sending off at intervals pairs of sm.ll arteries to the large masses of muscles filling the abdominal cavity; the lower is the second or sternal artery, which connects with one extending along the floor of the body near the thoracic ganglia of the nervous cord. There are no veins such as are present in the Vertebrates, but a series of venous channels or sinuses, through which the blood returns to the heart. There is, however, a large vein in the middle of the ventral side of the body.

The blood is driven by the heart through the arteries, and

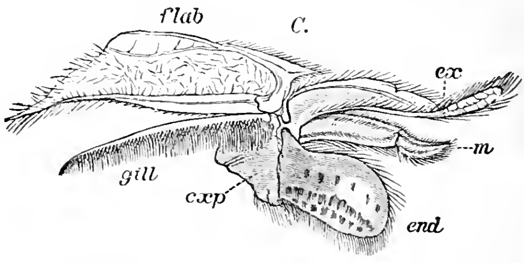


FIG. 97. — *C*, first maxillipede of lobster.

a large part of it, forced into the capillaries, is collected by the ventral venous sinus, and thence passing through the gills (Fig. 97, *gill*, where it is oxygenated, returning to the heart.

The gills are appendages of the three pairs of maxillipedes and the five pairs of feet, and are contained in a chamber formed by the carapace; the sea-water passing into the cavity between the body and the free edge of the carapace is afterwards scooped out through a large opening or passage on each side of the head, by a membranous appendage of the leg, called the "gill-paddle" (*flabellum*, Fig. 99).

The digestive system consists of a mouth, opening between the mandibles, an œsophagus, a large, membranous stomach, with very large teeth for crushing the food within the large or cardiac portion, while the posterior or pyloric end forms a strainer through which the food presses into the long, straight intestine, which ends in the telson. The liver is very large, dark green, with two ducts emptying on each side into the junction of the stomach with the intestine.

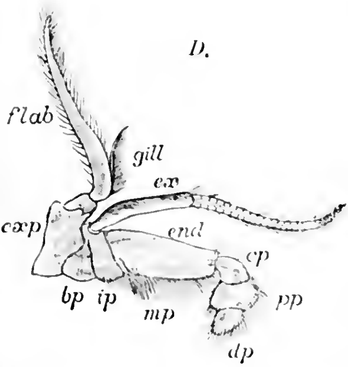


FIG. 98. — *D*, second maxillipede; *ex*, exopodite; *end*, endopodite; *flab*, epipodite or flabellum, or scaptogathnite.

The nervous system consists of a brain situated directly under the base of the rostrum (supraœsophageal ganglion), from which a pair of optic nerves go to the two eyes, and a pair to each of the four antennæ. The mouth-parts are supplied with nerves from the infraœsophageal ganglion, which, with the rest of the nervous system, lies in a lower plane than the brain. There are behind these two ganglia eleven others; the cephalo-thoracic portion of the cord is protected above by a framework of solid processes, which forms, as it were, a "false-bottom" to the cephalo-thorax; this has to be carefully removed before the nervous cord can be laid bare. A sympathetic nerve arises on each side of the œsophagus and distributes branches to the stomach.

The nerves of special sense are the optic and auditory nerves. The eyes are compound, namely, composed of many simple eyes, each consisting of a *cornea* and *crystalline cone*, connected behind with a long, slender *connective rod*, uniting the cone with a spindle-shaped body resting on or against an expansion of a fibre of the optic nerve, and is ensheathed by a retina or black pigment mass.

The lobster's ears are seated in the base of the smaller or first antennæ; they may be detected by a clear, oval space on the upper side; on laying this open, a large capsule will be discovered; inside of this capsule is a projecting ridge covered with fine hairs, each of which contains a

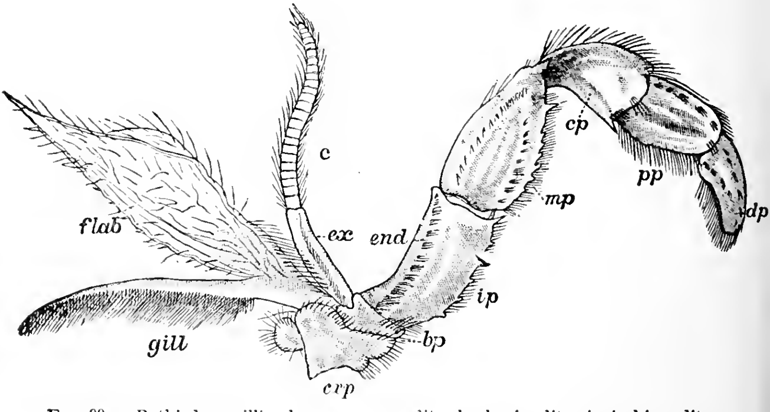


FIG. 99. — *B*, third maxillipede; *cxp*, coxopodite; *bp*, basipodite; *ip*, ischiopodite; *mp*, meropodite; *cp*, carpopodite; *pp*, propodite; *dp*, dactylopodite; *c*, multiarticulate extremity of exopodite or palpus; *flab*, epipodite or flabellum.

minute branch of the auditory nerve. The sac is filled with water, in which are suspended grains of sand which find their way into the capsule. A wave of sound disturbs the grains of sand, the vibrations affect the sensitive hairs, and thus the impression of a sound is telegraphed along the main auditory nerve to the brain.

The fine hairs fringing the mouth-parts and legs are organs of touch. The seat of the sense of smell in the Crustacea is not yet known, but it must be well developed, as nearly all Crustacea are scavengers, living on decaying matter. Crabs also have the power of finding their way back to their original habitat when carried off even for several miles.

The lobster spawns from March till November; the young are hatched with much of the form of the adult, not passing through a metamorphosis, as in most shrimps and crabs. They swim near the surface until about one inch long, afterwards remaining at or near the bottom.

The lobster probably moults but once annually, during the warmer part of the year, after having nearly attained its maturity, and when about to moult, or cast its skin, the carapace splits from its hind edge as far as the base of the rostrum or beak, where it is too solid to separate. The lobster then draws its body out of the rent in the anterior part of the carapace. The claw—at this time soft, fleshy, and very watery—is drawn out through the basal joint, which is partly absorbed to allow the flesh to pass through the joint. In moulting, the stomach, with the solid teeth, is cast off with the old integument.

Orders of Crustacea.

Order 1. Feet leaf-like, body usually with a bivalve shell.... ...*Branchiopoda*: Brine Shrimp, etc.

Order 2. Small, active, with free limbs; some parasitic.........*Entomostraca*: Cyclops, Fish-lice.

Order 3. Large, fixed, body protected by a shell of several pieces........................*Cirripedia*: Barnacles.

Order 4. Body flat or compressed; no carapace; eyes sessile..... *Tetradecapoda*: Pill-bug, Beach-fleas.

Order 5. Thoracic feet leaf-like; thorax covered by a carapace..*Phyllocarida*: Nebalia.

Order 6. Body partly covered with a large carapace; feet with gills; eyes stalked.......*Thoracostraca*: Shrimps, Crabs.

Literature.—*Milne-Edwards*, Histoire Naturelle des Crustacés. 3 vols. 1834–40.—*Dana*, Crustacea of the U. S. Exploring Expedition. 2 vols. 1852.—*Gerstaecker*, Arthropoden (in Bronn's Classen und Ordnungen des Thierreichs, 1866–91. 2 vols.—*Huxley*, The Crayfish, 1880.—*Packard*, Monograph of North American Phyllopod Crustacea, 1883.—Also the writings of Say, Dohrn, Sars, Claus, Brooks, Hagen, Faxon, Smith, Kingsley, etc.

Order 1. *Cirripedia.*—The barnacles would, at a first glance, hardly be regarded as Crustacea at all, so much modified is the form, owing to their fixed, parasitic mode of life. The barnacle is, as in the common sessile form (Fig. 100), a shell-like animal, the shell composed of several pieces, with a conical movable lid, having an opening through which several pairs of long, many-jointed, hairy appendages are thrust, thus creating a current which sets in towards the mouth. The common barnacle (*Balanus balanoides*) abounds on every rocky shore from extreme high-water mark to deep water, and the student can, by putting a group of them in sea-water, observe the opening and shutting of the valves and the movements of the hairy appendages.

FIG. 100.—A barnacle. *Balanus porcatus.* Natural size.

The metamorphosis of the barnacle is remarkable. After leaving the egg, it swims about as a minute *Nauplius* or

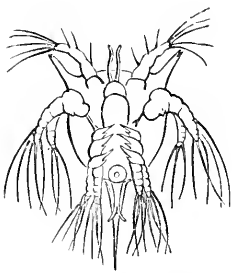


FIG. 101.—Nauplius of *Balanus balanoides.* Much enlarged.

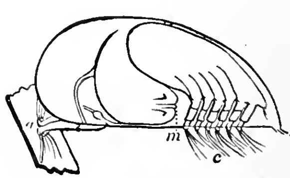


FIG. 102.—Pupa of *Lepas.* Much enlarged.

larva (Fig. 101), with three pairs of legs. Finally the larva attaches itself by its antennæ to some rock, and now a strange transformation follows. The body and legs (the number of legs having meanwhile increased, are enclosed by two sets of valves, so that the animal appears as if bivalved (Fig. 102), and at last the barnacle-shape is attained.

Order 2. *Entomostraca* (Water-fleas).—The type of this group is *Cyclops* (Fig. 103), in which the body is pear-

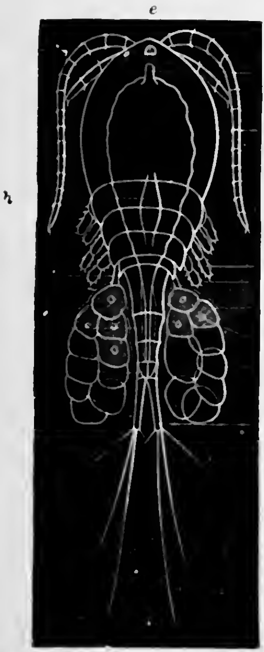


Fig 103.—*Cyclops*. *e*, eye; *h*, heart; *eg*, eggs; *f*, feet. Highly magnified.

Fig. 104.—Lernæa of the cod. *h*, head; *ov*, ovary. Nat. size.

Fig. 105. Fish louse of the menhaden.

shaped, with a single bright eye in the middle of the head; it has two pairs of antennæ, used for swimming as well as feelers; biting mouth-parts, and short legs. The females swim about with two egg-masses attached to the base of the abdomen. The young is a Nauplius, much like that represented in Fig. 112), the mouth-organs, the legs and abdominal segments arising after successive moults, until the adult form is attained.

Many *Entomostraca* are parasitic, living on the gills of fishes, etc., and consequently undergo a retrograde development, losing the jointed structure of the body, the appendages being more or less aborted, while the body increases greatly in size. Such are the fish-lice, represented

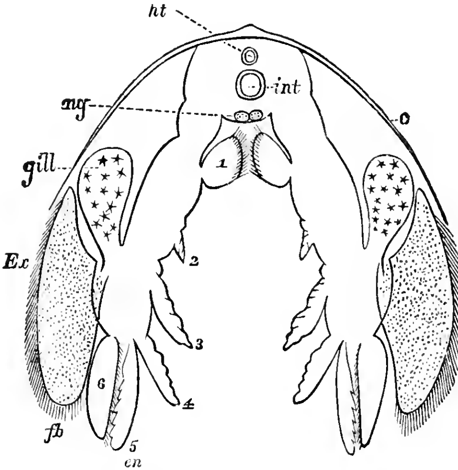


FIG 106.—Section through the thorax of Apus: *en*, 1-6, the six endites; *ex*, exopodal or respiratory portion of the limb forming the flabellum, *fb*; *c*, carapace; *ht*, heart; *int*, intestine; *ng*, nervous cord.

by the *Lernæa* of the cod (Fig. 104) or the fish-louse of the menhaden (Fig. 105).

Order 3. *Branchiopoda* (Bivalved Crustacea).—All the Crustacea hitherto mentioned breathe through their skin, having no gills; we now come to Crustacea whose body is protected by a rather thick shell or carapace, and which breathe by gills attached to the legs, or by broad gill-like expansions of the legs. In this order the number of segments varies from about 12 to 60; and the shield or carapace mostly covers the legs. Fig. 106 represents a section through the body of *Apus*; *C* is the carapace concealing the body and feet; 1–6 are the six lobes of the legs, to the outer side of which are attached the gill and the broad accessory gill (*fb*).

The simplest Branchiopods are bivalved, and are usually

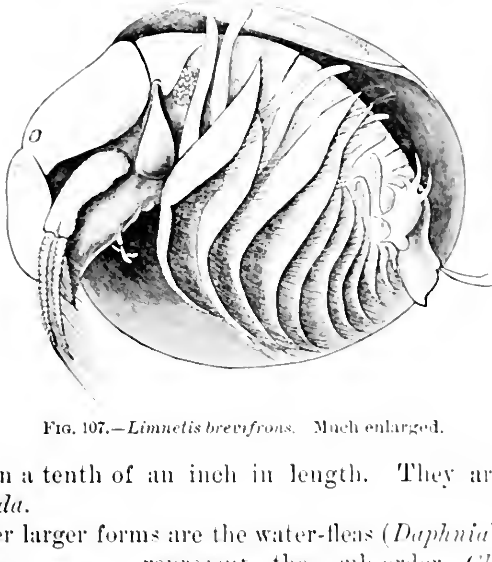


FIG. 107.—*Limnetis brevifrons.* Much enlarged.

less than a tenth of an inch in length. They are called *Ostracoda*.

Rather larger forms are the water-fleas (*Daphnia*), which represent the sub-order *Cladocera*. The most interesting sub-order is the *Phyllopoda*. In them (Fig. 107, *Limnetis*) and *Estheria* (Fig. 108) the body and legs are entirely concealed by the large bivalve shell. In *Apus* (Fig. 109) and *Lepidurus* (Fig. 110) the shield is broad and flat, concealing but a part of the body. In *Branchipus* (Fig. 111), which is common in roadside pools and in ponds in the cooler parts of the year, there is no carapace. The Phyllopods swim on their backs. *Apus* is remarkable for having 47 segments in all, and 60 pairs of limbs; certain segments bearing as many as six pairs of limbs. All the

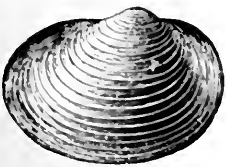


FIG. 108.—Shell of *Estheria Belfragei*; a shelled Phyllopod.

Phyllopods hatch in the form of a minute Nauplius (Fig. 112), additional segments and limbs being acquired during

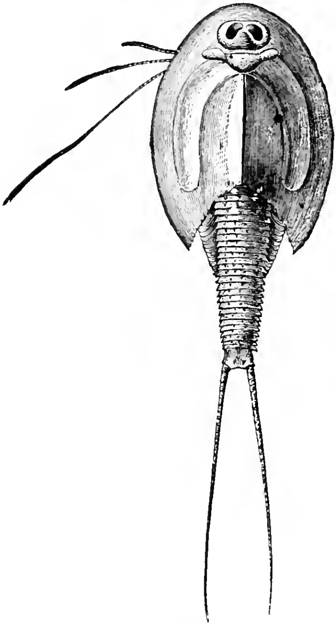


FIG. 109.—*Apus æqualis.* Natural size.

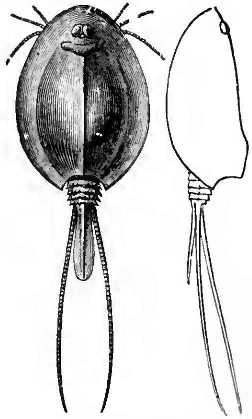


FIG. 110.—*Lepidurus Couesii*, side and dorsal view. Natural size.

successive moults or changes of skin. The brine shrimp (Fig. 113) resembles *Branchipus*, but is much smaller; it

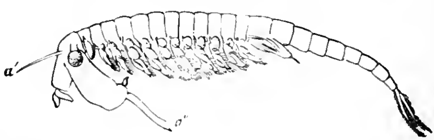


FIG. 111.—*Branchipus vernalis.* *a'*, 1st antenna; *a''*, 2d antenna. Slightly enlarged.

inhabits Great Salt Lake in Utah and other salt lakes in the West and in the Old World, as well as tubs on railroad bridges, where salt water has evaporated and become briny.

Order 4. Tetradecapoda.—To this order belong the sow-bugs (*Isopoda*) and the beach-fleas (*Amphipoda*). They have no carapace, but the head is small, bearing two pairs of antennæ, and a pair of jaws, and three pairs of maxillæ.

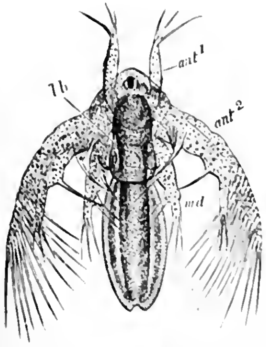


FIG. 112.—Nauplius of *Branchipus stagnalis.* *ant*¹, 1st antenna; *ant*², 2d antenna; *md*, mandible; *lb*, under lip. Much enlarged.

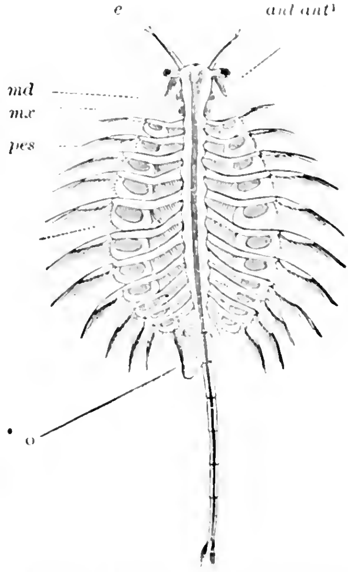


FIG. 113.—Brine Shrimp (*Artemia gracilis*), seen from above, much enlarged. *e*, eye; *ant*, 1st antennæ; *ant*¹, 2d antennæ; *md*, mandibles; *mx*, maxillæ. *pes*, foot; *o*, ovisack.

The thorax is continuous with the abdomen. They breathe by leaf-like gills, which are situated on the middle feet in the Amphipods, or on the hinder abdominal feet in the Isopods. The various species of *Porcellio* (sow-bug) live under stones on land; and allied to *Asellus*, the water sow-bug, is the marine *Limnoria terebrans*, which is very injurious to the piles of bridges, wharves, and any submerged wood. The highest Isopods are *Idotæa*, of which *I. irroratus* is our most abundant species, being common in eel-grass, etc., between and just below tide-marks. While the

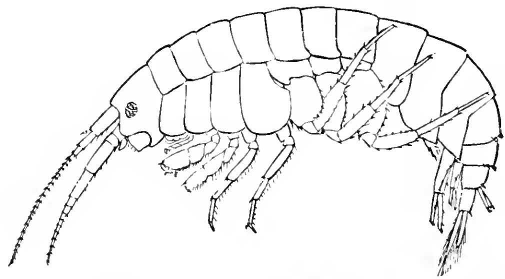


FIG. 114.—*Gammarus robustus*, from fresh water. Much enlarged.

Isopods are broad and flat, the Amphipods are compressed, and the back is usually more or less arched. Such is the

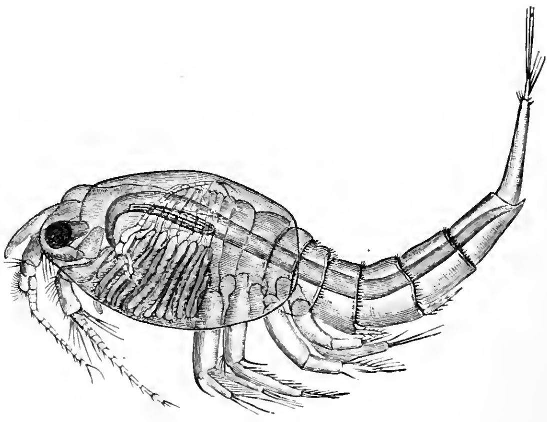


FIG. 115.—*Nebalia bipes.* Enlarged 6 times.

Gammarus, or beach-flea (Fig. 114), found in salt and fresh water.

Order 5. *Phyllocarida.*—This group is represented by a little Crustacean, with a compressed body, and broad leaf-

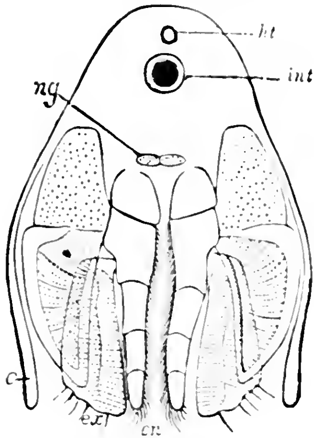


FIG. 116.—Partly diagrammatic section through the thorax of Nebalia. *en*, the axial-jointed endopodite; *ex*, exital portion or gill (above irregularly dotted) and flabellum below with transverse rows of dots; *c*, carapace; *ht*, heart; *int*, intestine; *ng*, nervous system.

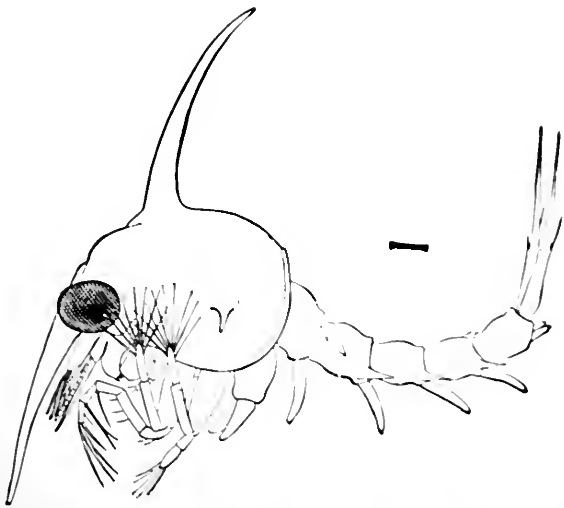


FIG. 117.—Zoëa of the common Crab (*Cancer irroratus*). Much enlarged.

like feet covered by the carapace. The *Nebalia bipes* (Figs. 115, 116) occurs along our coast.

Order 6. *Thoracostraca* (Shrimps, Lobsters, Crabs).—This order includes the Decapods, which have ten feet arranged in five pairs, the first pair enlarged, forming "nippers;" the head and thorax are covered by a solid, thick carapace; while the gills are attached to the hinder maxillipedes and to the thoracic feet. The Decapods pass through a metamorphosis, the young being termed a *zoëa* (Fig. 117).

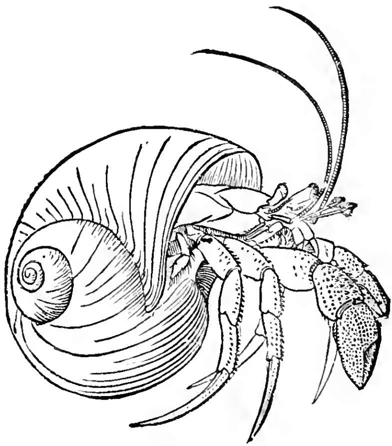


FIG. 118.—Common Hermit Crab. Natural size. After Morse, from Emerton.

A curious creature is the hermit crab (Fig. 118, *Eupagurus bernhardus;* see also Fig. 19), which, selecting an empty shell, thrusts its soft hind-body into it, and uses it as a protection—like Diogenes, carrying its house about with it. Small hermit crabs are abundant in little shells in tidal pools along our coast.

In the crabs (Fig. 119) the abdomen is very small and folded to the under side of the head-thorax (cephalo-thorax). Shrimps and crabs are sensitive to shocks and sounds. The sense of touch resides in the hairs on the mouth-parts.

Class II.—Podostomata (*King-crab, Eurypterus, and Trilobites*).

Order 1. *Merostomata.*—The only living representative of this order is the horseshoe or king-crab (*Limulus Polyphemus*, Fig. 122), which ranges from Casco Bay, Maine, to Florida and the West Indies.

The body of the king-crab is very large, sometimes nearly two

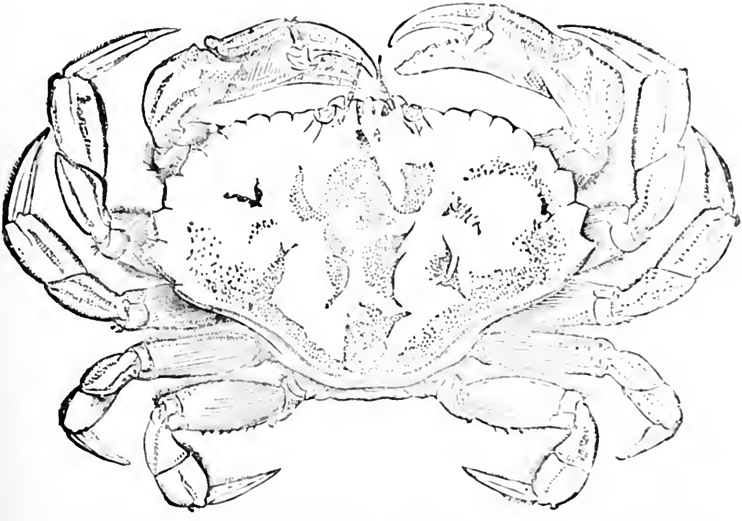


Fig. 119.—Common Shore-crab (*Cancer irroratus*). Natural size. From Emerton.

feet in length; it consists of a head composed of six segments and an abdomen with nine segments, the ninth (telson) forming a long spine. The head is broader than long, in shape somewhat like that of *Apus*, with a broad flat triangular fold on the under side. Above are two large lunate compound eyes, near the middle of the head, but quite remote from each other, and two small compound eyes situated close together near the front edge of the head. There are no antennæ, and the six pairs of appendages are of uniform shape like legs, not like mandibles or maxillæ, and are adapted for walking; the feet are provided with sharp teeth on the basal joint for retain-ing the food, which the horseshoe obtains by burrowing in the mud or sand. The mouth is situated between the second pair; the first pair of legs are smaller than the others. All end in two simple

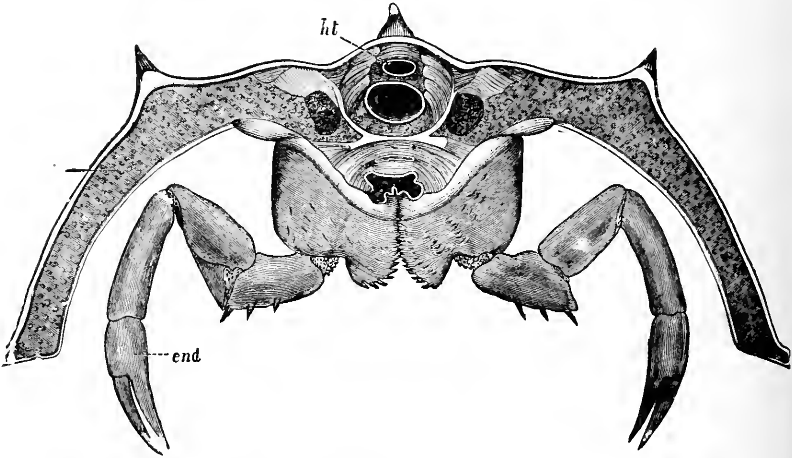


FIG. 120.—Actual section through the head of Limulus, showing the second pair of appendages and their relations to the shell or carapace. *ht*, heart; *liv*, liver; *end*, appendage homologous with the endopodite of Decapoda.

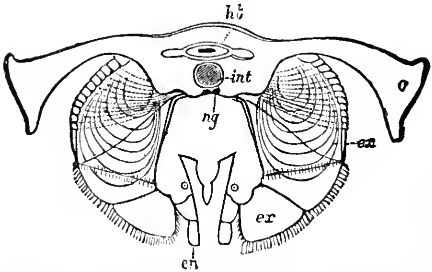


FIG. 121.—Section through the abdomen of Limulus. *c*, carapace; *ht*, heart; *int*, intestine; *ng*, ganglia (lettering being the same as in Fig. 123); *en*, axial, jointed endopodite; *ex*, exital or respiratory portion bearing the gill-lamellæ; the outer division (*ex*) homologous with the exopodal portion of the Phyllopod and Phyllocaridan leg.

claws (Fig. 120), except the sixth pair, which are armed with several spatulate appendages serving to prop the creature as it burrows into the mud. Appended to the abdomen are six pairs of broad swimming feet (Fig. 121, *ex*), of which all but the first pair bear on the under side a set of about one hundred respiratory leaves or plates, into which the blood is sent from the heart, passing around the outer edge and returning around the inner edge.

In order to examine the internal anatomy the student can readily with a knife cut the body into transverse sections, as in Figs. 120, 121, and also divide it longitudinally so as to show the parts as in Fig. 123.

The alimentary canal consists of an œsophagus, which rises directly over the mouth, a stomach lined with rows of large chitinous teeth, with a large conical, stopper like valve projecting into the posterior end of the body; the intestine is straight, ending in the base of the abdominal spine. The liver is very voluminous, ramifying throughout the cephalothorax. The nervous system is quite unlike that of other Crustacea; the brain is situated on the floor of the body in the same plane as the rest of the system, and sends off two

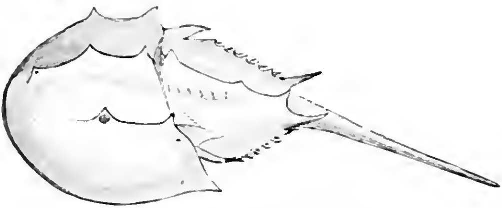


FIG. 122.—Horseshoe Crab. Side view.

pairs of nerves—a pair to each pair of eyes. The feet are all supplied with nerves from a thick nervous ring surrounding the œsophagus. The nerves to the six pairs of abdominal legs are sent off from the ventral cord.

The eggs of the horseshoe crab are rather large, and laid in the sand between high and low water. Just before it hatches it strikingly resembles a trilobite. After leaving the egg (Fig. 124) it swims about on its back or burrows in the sand; at first it has no tail-spine, this growing out at successive moults. In casting its shell the latter splits open in front, so that during the process it appears as if spewing itself out. Specimens a foot long are probably several years old.

Order 2. Trilobita.—The members of this group are all extinct. The body has a thick dense skin like that of

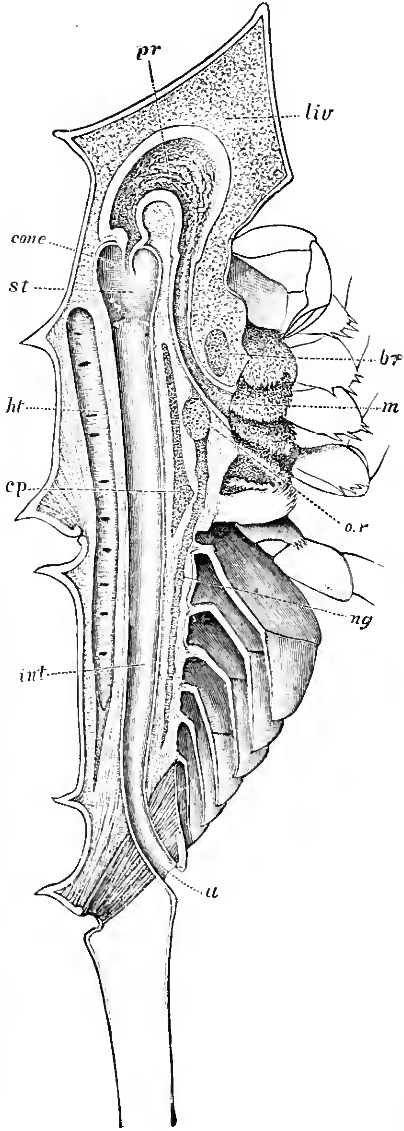


FIG. 123.—Section through a small *Limulus Polyphemus* (enlarged three times), to compare with a Phyllopod Crustacean such as Apus. *liv*, liver; *pr*, proventriculus; *st*, stomach; *ht*, heart; *cp*, cartilaginous plate over the nervous system; *int*, intestine; *a*, anus; *br*, brain; *m*, mouth; *or*, œsophageal nervous ring; *ng*, abdominal ganglia.

Limulus, and is often variously ornamented with tubercles and spines. The body is divided into three longitudinal lobes, the central situated over the region of the heart as in *Limulus*. The body differs from that of the

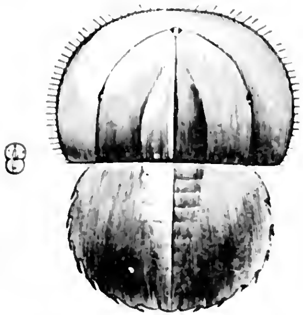


FIG. 124.—Young Horseshoe Crab. Natural size and enlarged.

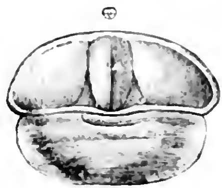


FIG. 125.—Young Trilobite. Natural size and enlarged.

horseshoe crab in being divided into a true head consisting of six segments bearing jointed appendages, somewhat like those of the *Merostomata*, with from two to twenty-six distinct thoracic segments (probably bearing short jointed

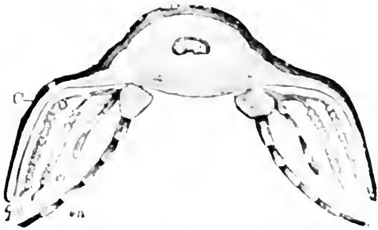


FIG. 126.—Restored section of the thorax of a trilobite (Calymene) after Walcott. *c*, carapace; *en*, endopodite; *ex*, exopodite, with the gills on the exopodal or respiratory part of the appendage.

limbs not extending beyond the edge of the body). The abdomen consists of several (greatest number twenty-eight) coalesced segments, forming a solid portion (*pygidium*), sometimes ending in a spine. The larval trilobite (Fig. 125) was like that of a king-crab, and after a number of moults acquired its thoracic segments, there being in most of them a well-marked metamorphosis. The Trilobites occur in the oldest fossiliferous rocks. Fig. 126 is an attempt by Mr. C. D. Walcott to represent a restoration of a cross-section of a trilobite, showing the relations of the feet and gills to the body; the gills being spirally twisted filaments growing from the base of the legs.

INSECTA AND OTHER AIR-BREATHING ARTHROPODA.

General Characters of Insects.—In the insects the head is separated from the rest of the body, which is divided into three regions, the head, thorax, and hind-body (abdomen); hence the name insect, from *insectum*, cut into or divided. Insects breathe by internal air-tubes which open through breathing-holes (spiracles) in the sides of the body. The six-footed insects also have two pairs of wings.

The number of body-segments in winged insects is seventeen or eighteen—*i.e.*, four in the head, three in the thorax, and ten or eleven in the hind-body. In spiders and mites there are usually but two segments in the head, four in the thorax, and a varying number (not more than twelve) in the abdomen; in Myriopods the number of segments varies greatly—*i.e.*, from ten to two hundred. The appendages of the body are jointed.

Of the winged insects there are two types: first, those in which the jaws and maxillæ are free, adapted for biting, as in the locust or grasshopper; and, second, those in which the jaws and maxillæ are more or less modified to suck or lap up liquid food, as in the butterfly, bee, and bug.

Nearly all insects undergo a metamorphosis, the young being called a *larva* (caterpillar, grub, maggot); the larva transforms into a *pupa* (chrysalis), and the pupa into the adult (imago).

In order to obtain a knowledge of entomology, the beginner should make a careful study of a locust or grasshopper with the aid of the following description; and afterward rear from the egg a caterpillar and watch the different

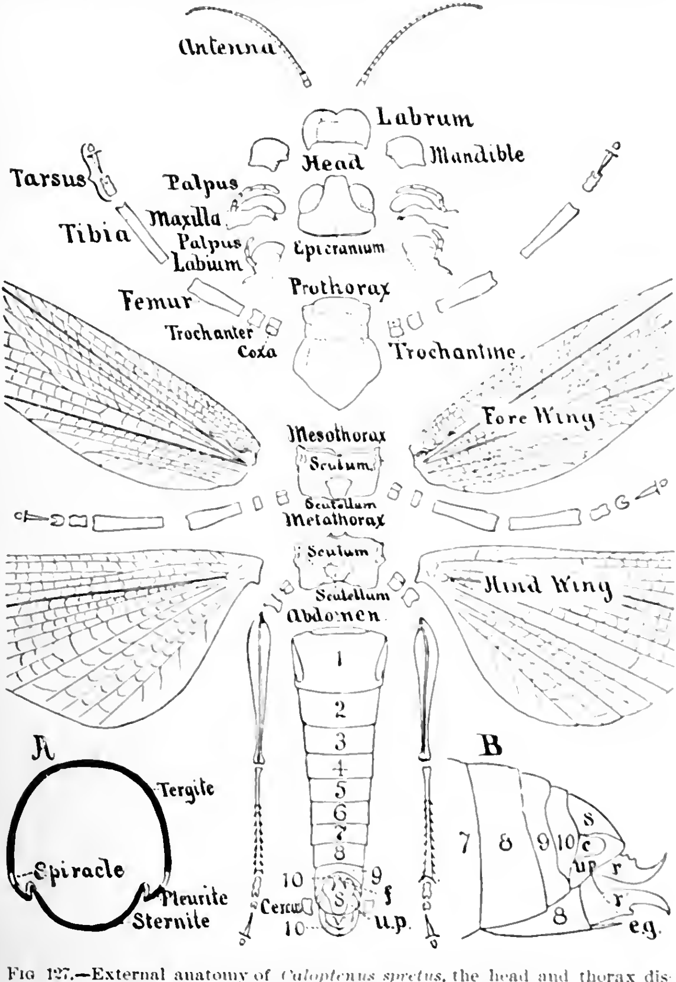


FIG 127.—External anatomy of *Caloptenus spretus*, the head and thorax disjointed. *up*, uropatagium; *f*, furcula; *c*, cercopod.

steps in its metamorphosis into a pupa and adult. The knowledge thus acquired will be worth more to the student than a volume of descriptions.

On making a superficial examination of the locust (*Caloptenus femur-rubrum*), its body will be seen to consist of an external crust, or thick, hard integument, protecting the soft parts within. This integument is at intervals segmented or jointed, the segments more or less like rings. These segments are most simple and easily comprehended in the abdomen or hind-body, which is composed of ten of them. On examining the abdomen, it will be found that the rings are quite perfect, and that each segment may be divided into an upper (tergal), a lateral (pleural), and an under (sternal) portion or arc (Fig. 127, *A*).

As these parts are less complicated in the abdomen, we will first study this region of the body, and then examine the more complex thorax and head. The abdomen is a little over half as long as the body, the tergum extending far down on the side and merging into the pleurum without any suture or seam. The pleurum is indicated by the row of spiracles, which will be noticed further on. The sternum forms the ventral side of the abdomen, and meets the pleurum on the side of the body.

In the female (Fig. 127, *B*), the abdomen tapers somewhat toward the end of the body, to which are appended the two pairs of stout, hooked spines, forming the ovipositor (Fig. 127, *B*, *r*, *r'*). The vent is situated above the upper and larger pair, and the external opening of the oviduct, which is situated between the smaller and lower pair of spines, and is bounded on the ventral side by a movable triangular acute flap, the egg-guide (Fig. 127, *B*, *eg*).

The thorax, as seen in Fig. 127, consists of three segments, called the prothorax, mesothorax, and metathorax, or fore, middle, and hind thoracic rings. They each bear a pair of legs, and the two hinder each a pair of wings. The upper portion of the middle and hind segments, owing to the presence of wings and the necessity of freedom of movement to the muscles of flight, are divided or differentiated into two pieces, the *scutum* and *scutellum* * (Fig. 127), the former the larger, extending across the back, and the scutellum a smaller, central, shield-like piece. The pronotum, or what is usually in the books called the prothorax, represents either the scutum or

* There are in many insects, as in many *Lepidoptera* and *Hymenoptera* and the *Neuroptera*, four tergal pieces, *i.e.*, præscutum, scutum, scutellum, and postscutellum, the first and fourth pieces being usually very small and often obsolete.

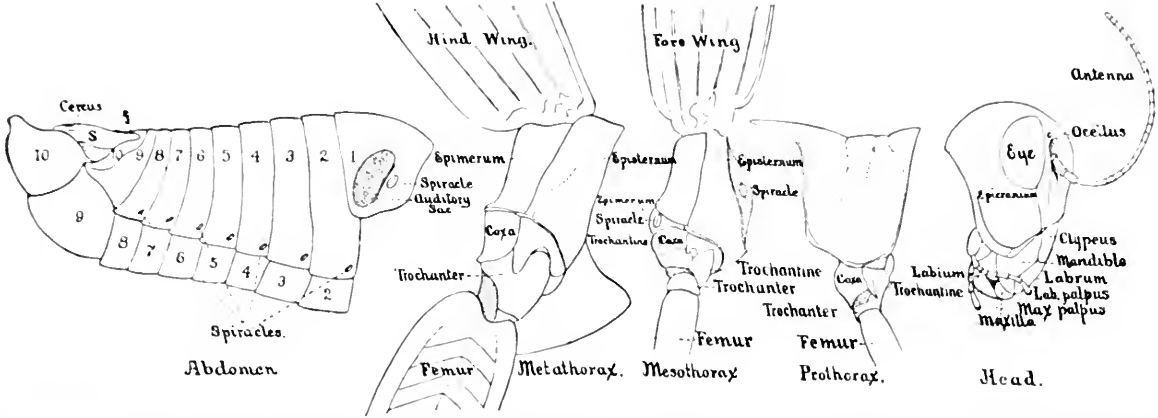


FIG. 128.—Male Locust, *Caloptenus spretus*, with the thorax separate from the head and abdomen, and divided into its three segments.

both scutum and scutellum, the two not being separately developed.

The fore wings are long and narrow, and thicker than the hinder, which are broad thin, and membranous, and most active in flight, being folded up like a fan when at rest and tucked away out of sight under the fore wings, which act as wing-covers.

Turning now to the side of the body (Fig. 128), we see that the side of each of the middle and hind thoracic rings is composed of two pieces, the anterior, *episternum*, resting on the sternum, with the *epimerum* behind it; these pieces are vertically high and narrow, and to them the leg is inserted by three pieces, called respectively *coxa*, *trochantine*, and *trochanter* (see Fig. 128), the latter forming a true joint of the leg.

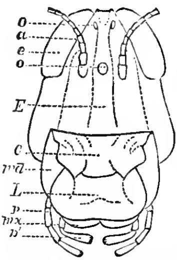


FIG 129.—Front view of the head of *C. spretus*. *E*, Epicranium; *C*, clypeus; *L*, labrum; *o o*, ocelli; *e*, eye; *a*, antenna; *md*, mandible; *mx*, portion of maxilla uncovered by the labrum; *p*. maxillary palpus; *p'*, labial palpus.

The legs consist of five well-marked joints, the *femur* (thigh), *tibia* (shank), and *tarsus* (foot), the latter consisting in the locust of three joints, the third bearing two large claws with a pad between them. The hind legs, especially the femur and tibia, are very large, adapted for hopping.

The sternum is broad and large in the middle and hind thorax, but small and obscurely limited in the prothorax, with a large conical projection between the legs.

The head is mainly in the adult locust composed of a single piece (called the *epicranium*, Figs. 128 and 129 *E*), which carries the compound eyes, ocelli, or simple eyes (Fig. 129, *e*), and antennæ. While there are in reality four primary segments in the head of all winged insects, corresponding to the four pairs of appendages in the head, the posterior three segments, after early embryonic life in the locust, become obsolete, and are mainly represented by their appendages and by small portions to which the appendages are attached. The antennæ, or feelers, are inserted in front of the eyes, and between them is the anterior ocellus, or simple eye, while the two posterior ocelli are situated above the insertion of the antennæ. In front of the epicranium is the *clypeus* (Fig. 129), a piece nearly twice as broad as long. To the clypeus is attached a loose flap, which covers the jaws when they are at rest. This is the upper lip or *labrum*) Fig. 129). There are three pairs of mouth-appendages: first, the true jaws or mandibles (Fig. 127), which are single-jointed, and are broad, short, solid, with a toothed cutting and grinding edge adapted for biting. The mandibles are situated on each side of the mouth-opening. Behind the mandibles are the maxillæ (Fig. 127), which are divided into three lobes, the inner armed with teeth or

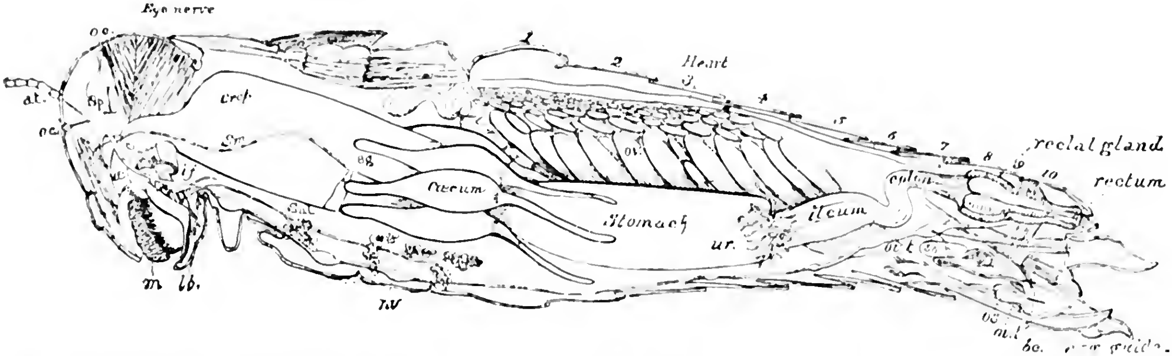


Fig. 130.—Internal anatomy of *Caloptenus femur-rubrum*. *at*, antenna and nerve leading to it from the "brain" or supra-œsophageal ganglion (*sp*); *oc*, ocelli, anterior and vertical ones, with ocellar nerves leading to them from the "brain;" *œ*, œsophagus; *m*, mouth; *lb*, labium or under lip; *if*, infra œsophageal ganglion, sending three pairs of nerves to the mandibles, maxillæ, and labium respectively (not clearly shown in the engraving); *sm*, sympathetic or vagus nerve, starting from a ganglion resting above the œsophagus, and connecting with another ganglion (*sg*) near the hinder end of the crop; *sal*, salivary glands (the termination of the salivary duct not clearly shown by the engraver); *nv*, nervous cord and ganglia; *ov*, ovary; *ur*, urinary tubes (cut off, leaving the stumps); *ovt*, oviduct; *sb*, sebaceous gland; *bc*, bursa copulatrix; *ovt'*, site of opening of the oviduct (the left oviduct cut away); 1-10, abdominal segments. The other organs labelled in full. Drawn from his original dissections by Mr. Edward Burgess.

spines, the middle lobe unarmed and spatula-shaped, while the outer forms a five-jointed feeler called the *maxillary palpus*. The maxillæ are accessory jaws, and probably serve to hold and arrange the food to be ground by the true jaws. The floor of the mouth is formed by the *labium* (Figs. 127 and 128), which in reality is composed of the two second maxillæ, grown together in the middle, the two halves being drawn separately in Fig. 127.

Within the mouth, and situated upon the labium, is the tongue (*lingua*), which is a large, membranous, partly hollow expansion of the base of the labrum; it resembles a beech-nut in shape, being slightly keeled above, and covered with fine, stiff hairs, which, when magnified, are seen to be long, rough, chitinous spines, with one or two slight points or tubercles on the side.

The internal anatomy may be studied by removing the dorsal wall of the body with fine scissors, and also by hardening the insect several days in alcohol and cutting it in two longitudinally by a sharp scalpel.

The *œsophagus* (Fig. 130, *œ*) is short and curved, continuous with the roof of the mouth. The two salivary glands consist each of a bunch of follicles, emptying by a common duct into the floor of the mouth.

The œsophagus is succeeded by the crop (*ingluvies*). It is in the crop that the "molasses" thrown out by the locust originates.

The *proventriculus* is very small in the locust, easily overlooked in dissection, while in the green grasshoppers it is rather large, and armed with sharp teeth. The true or chyle-stomach is about one half as thick as the crop.

From the anterior end arise six large pockets (*gastric cœca*), which arise from the true chyle-stomach, and probably serve to present a larger surface from which the chyle may escape into the body-cavity and mix with the blood, there being in insects no lacteal vessels or lymphatic system.

The stomach ends in a slight constriction, at which point the urinary tubes (Fig. 130, *ur*) arise. These are arranged in ten groups of about fifteen tubes, so that there are about one hundred and fifty long, fine tubes in all. The stomach is succeeded by the ileum, colon, and rectum (Figs. 130, 131).

The nervous system of the locust, as of other insects, consists of a series of swellings or nerve-centres, or so-called brains (ganglia), which are connected by two cords (commissures), the two cords in certain parts of the body in some insects united into one. There are in the locust ten ganglia, two in the head, three in the thorax, and five in the abdomen. The first ganglion is rather larger than the others, and is called the "brain." The brain rests upon the œsoph-

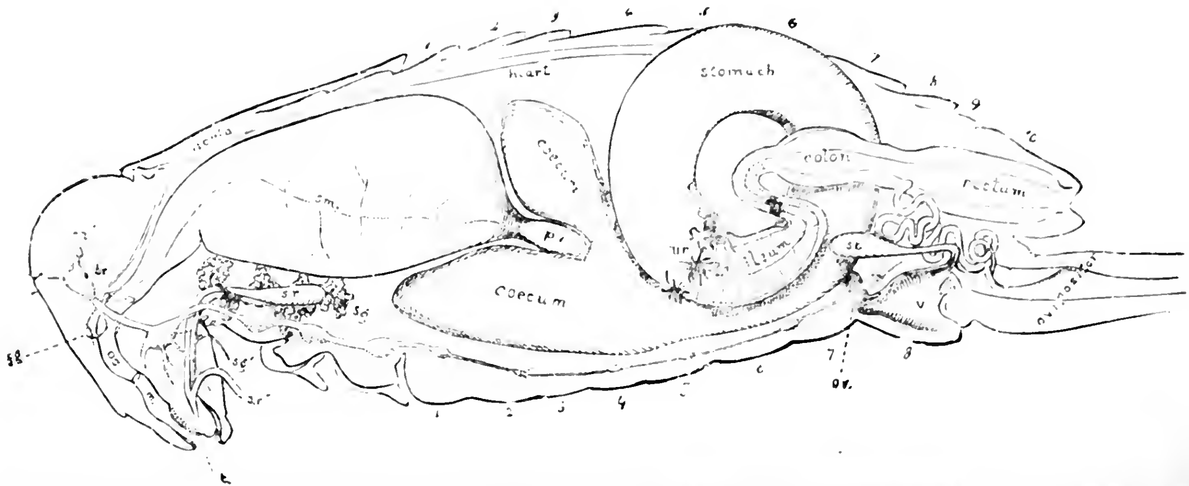


FIG. 131.—Internal anatomy of *Anabrus*. *t*, tongue; *fg*, frontal ganglion; *br*, brain, the nervous cord passing backward from it; *sr*, salivary reservoir; *pv*, proventriculus; *ur*, origin of urinary tubes; *sb*, sebaceous gland. Burgess *del.*

agus, whence its name, supra-œsophageal ganglion. From the brain arise the nerves to the eyes and feelers, and from it the nervous cord extends back to the end of the body.

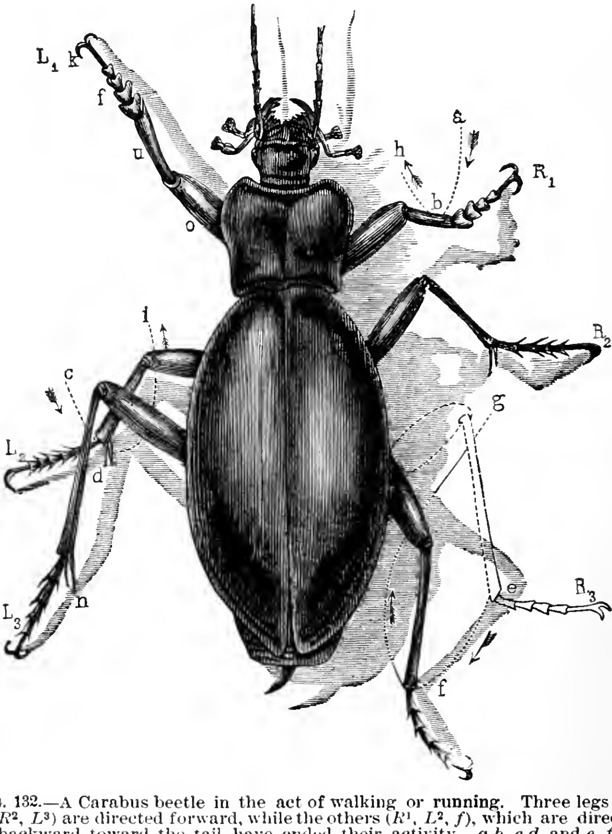


FIG. 132.—A Carabus beetle in the act of walking or running. Three legs (L^1, R^2, L^3) are directed forward, while the others (R^1, L^2, f), which are directed backward toward the tail, have ended their activity. *a b*, *c d*, and *e f* are curves described by the end of the tibiæ and passing back to the end of the body; *b h*, *d i*, and *f g* are curves described by the same legs during their passive change of position.

All insects breathe by means of a complicated system of air-tubes ramifying throughout the body, the air entering through a row of spiracles or breathing-holes (*stigmata*) in the sides of the body. There are in many insects two pairs of thoracic and eight pairs of abdominal spiracles. The anatomy of the grasshopper may also be compared with that of the western cricket (Fig. 131).

The antennae are both organs of touch and also of smell, the olfactory organs being little pits: some insects, however, hear with their antennae. The locusts have a pair of large ears situated at the base of the abdomen (Fig. 128).

Insects produce sounds in various ways, either as in locusts by rubbing the legs against the closed wings, or by rubbing the upper on the under or hind wings; while some insects produce creaking sounds by rubbing the harder parts of the body together.

In walking or running, an insect, as a beetle (Fig. 132), raises and puts down its six legs alternately, as may be seen by observing the movements of any large insect.

The wings are broad thin bags or expansions of the skin. They are strengthened by hollow rods called veins, of which there are six principal ones. The veins are hollow, usually containing an air-tube.

The wing of an insect in making the strokes during flight describes a figure 8 in the air. A fly's wing makes 330 revolutions in a second, executing therefore 660 simple oscillations.

According to M. Plateau, who has recently made ingenious experiments regarding the strength of insects, the smallest of these animals are proportionally the strongest. A cockchafer can pull 21 times more, proportionally, than a horse, while a bee pulls thirty times more. (The animals were attached to a cord passing over a pulley to a weighted scale.) The horse lifts 6-7ths of its weight, the cockchafer 14 times its weight, and the bee 20 times.

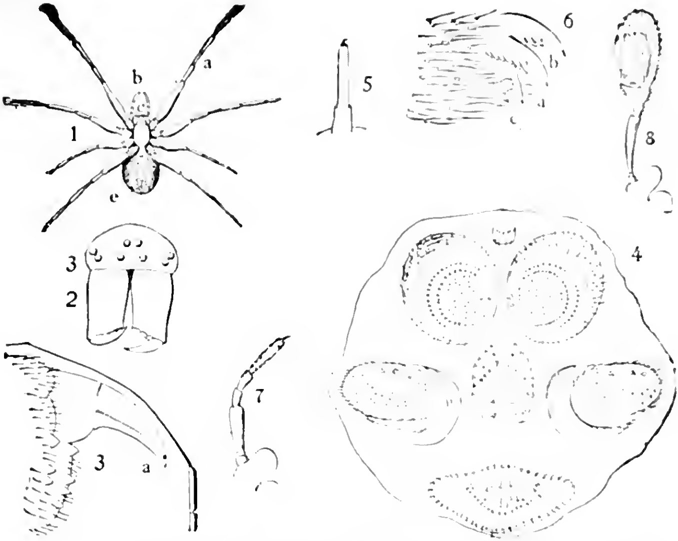
Insects are very prolific, laying hundreds of eggs. Some insects, as the cricket, grasshopper, and ichneumon fly, possess a horny tube called an *ovipositor*, by means of which they bore into wood or the earth and deposit their eggs one after another.

After hatching from the egg, insects pass through a series of changes of form called a metamorphosis. The butterfly passes through four stages: 1, the egg; 2, the caterpillar or *larva;* 3, the chrysalis or *pupa;* and, 4, the *imago* or adult insect. In the grasshopper the perfect or adult insect differs chiefly from the larva in having wings; in such insects the metamorphosis is said to be *incomplete;* while the butterfly and bee have a *complete* metamorphosis, the larva or caterpillar being entirely unlike the *imago* or perfect insect.

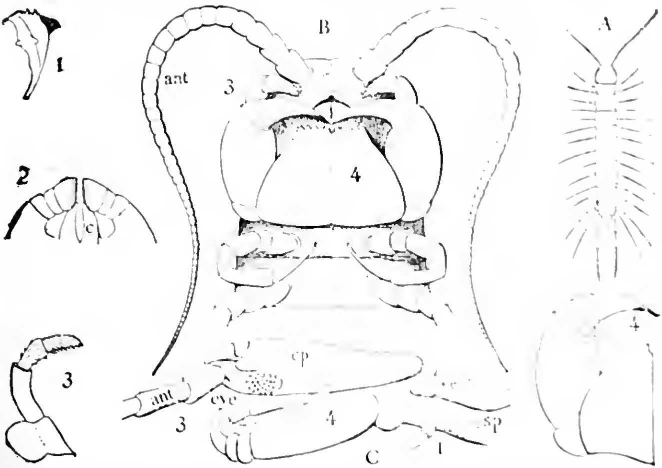
Insects are both useful and injurious to vegetation. Were it not for certain bees and moths, orchids and many other plants would not be fertilized; insects also assist in the cross-fertilization of plants. For full crops of many of our fruits and vegetables, we are largely indebted to bees, flies, moths, and beetles, which, conveying pollen from flower to flower, ensure the production of abundant seeds and fruits. Mankind, on the other hand, suffers enormous losses from the attacks of injurious insects. Within a period of four years, the Rocky Mountain locust, migrating eastward, inflicted a loss of $200,000,000 on the farmers of the West. In the year 1864 the losses occasioned by the chinch-bug in the corn and wheat crop of the valley of the Mississippi amounted to upward of $100,000,000. It is estimated that the average annual losses in the United States from insects is about $100,000,000. On the other hand, hosts of ichneumon flies and Tachina flies reduce the numbers and usually prevent undue increase in the numbers of injurious insects.

The number of species of insects in collections is about 200,000. Of these there are about 25,000 species of *Hymenoptera* (bees, wasps, etc.); about 25,000 species of *Lepidoptera* (butterflies and moths); about 25,000 *Diptera* (two-winged flies), and 90,000 *Coleoptera* (beetles); with about 4600 species of *Arachnida* (spiders, etc.), and 800 species of *Myriopoda* (millepedes, centipedes, etc.).

Insects are distributed all over the surface of the earth,

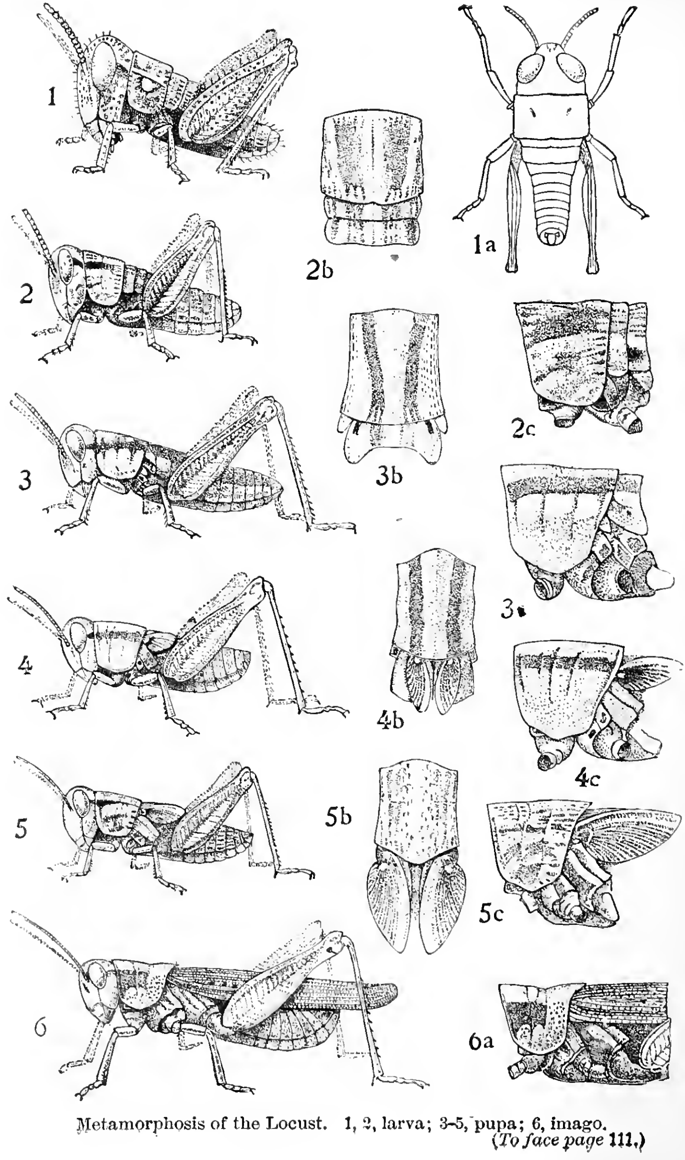


The common garden spider (*Epeira*): *a*, leg; *b*, maxillary palpus; *c*, poison-jaws; *e*, spinnerets. 2 Front view of head with the eight simple eyes and the poison-jaws. 3. End of a jaw: *a*, outlet of the poison-canal. 7. Palpus of female; 8, of male spider. 6. Spines and claws at end of a leg. 4. Spinnerets, highly magnified. 5. A single silk tube.—After Emerton.



Structure of a centipede. *A*, *Lithobius americanus*, natural size. *B*, under side of head and first two body-segments and legs, enlarged: *ant*, antenna; 1, jaws; 2, first accessory jaw; *c*, lingua; 3, second accessory jaw and palpus; 4, poison-jaw. (Kingsley del.) *C*, side view of head (after Newport): *ep*, epicranium; *l*, frontal plate; *sc*, scute; *p*, first leg; *sp*, spiracle.

(*To face page* 110.)



Metamorphosis of the Locust. 1, 2, larva; 3–5, pupa; 6, imago.
(*To face page* 111.)

Most of the species are confined to the warmer portions of the globe, becoming fewer as we approach the North Polar regions. Many are inhabitants of fresh water; a very few inhabit the sea.

The Myriapods are all terrestrial, and occur in all parts of the earth except the polar regions. On the other hand, spiders and mites occur in tolerable abundance in the arctic regions, as well as on the summits of lofty mountains, but the scorpions are confined to the hotter parts of the earth.

Unlike the winged insects, the Myriapods and Arachnids do not pass through a well-marked metamorphosis.

Class III.—Malacopoda.

General Characters of Malacopoda.—This group is represented by a single animal, the *Peripatus* of the tropics, in which the soft worm-like body has rudimentary jaws. There is a pair of fleshy feet, ending in two claws, to each segment; it breathes by minute air-tubes.

Class IV.—Myriapoda.

General Characters of Myriapods.—The centipedes and millepedes are distinguished by their cylindrical body, the abdominal segments being numerous and similar to the thoracic segments, all provided with a pair of feet. The head is free, with a pair of antennæ, and two or three pairs of jaw-like appendages.

Order 1. *Chilognatha.*—To this group belong the millepedes, *Julus*, etc. (Fig. 133). The segments are round or flattened, and the feet are inserted near together, and there appear to be two pairs to each segment. Millepedes feed on dead, sometimes fresh leaves, and on fallen fruit.

Order 2. *Chilopoda.*—This group is represented by the centipede, in which the body is flattened. In *Geophilus* (Fig. 134, *G. bipuncticeps*) there are from thirty to two hundred segments. Our most common form is *Lithobius*

Americanus, found under logs, etc. The centipede (*Scolopendra heros*) is very poisonous, the poison-sacs being lodged in the two large fangs or second pair of jaw-legs.

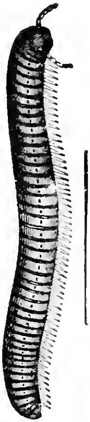


FIG. 133.—Julus.

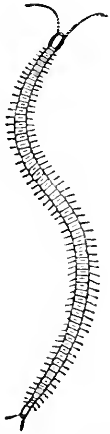


FIG 134.—*Geophilus*. Natural size.

CLASS V.—ARACHNIDA.

General Characters of Arachnids.—The bodies of spiders and scorpions, etc., are divided into two regions, a head-thorax and abdomen, the head being closely united with the thorax. There are no antennæ, only a pair of mandibles and a pair of maxillæ, with four pairs of legs. There are never any compound eyes. The young are usually like the adult, except in the mites, in which there is a slight metamorphosis, the young being born with but three pairs of legs, while the full-grown mite has four pairs.

An example of the sub-class is the spider, which is characterized by having two or three pairs of spinnerets, out of which the silk is drawn in spinning their webs. Besides breathing by air-tubes, spiders have so-called lungs composed of several leaves, into which the blood flows.

ORDERS OF ARACHNIDA.

1. Body small, rounded; no distinct abdomen. *Acarina*, Mites.
2. Body with a jointed abdomen .... *Arthrogastra*, Scorpion
3. Body with a thick unjointed abdomen..... *Araneina*, Spiders.

Order 1. *Acarina*.—The mites (Fig. 135) are the simplest Arachnida, the body being oval in form, the head usually small, more or less merged with the thorax, while the latter is not separate from the abdomen. The tick

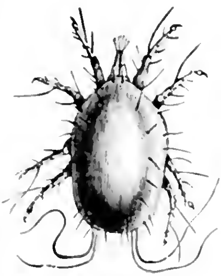


FIG. 135.—Sugar-mite. Much enlarged.

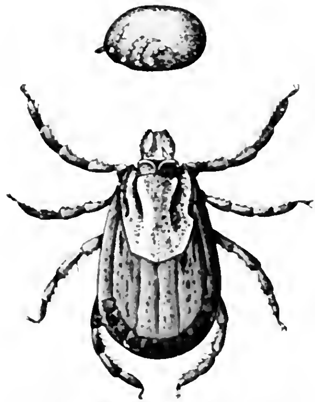


FIG. 136.—Cattle tick (*Ixodes bovis*). Natural size and enlarged.

(Fig. 136) is a large mite. It infests cattle, sometimes burying itself in the skin of human beings.

Order 2. *Arthrogastra*.—This group embraces the scorpion (Fig. 137), the false-scorpions, the whip-scorpions, and the harvest-men (*Phalangium*). In all these forms the abdomen is plainly segmented, the segments not being visible in the mites or spiders. Usually the maxillary palpi are much enlarged, and end in claws. The scorpion is viviparous, the young being brought forth alive. The young scorpions cling to the back of the mother. The sting of the scorpion is lodged in the tail, which is perforated, and contains in the bulbous enlargement an active poison. Though producing sickness, pain, and swelling in the part wounded, the sting of the scorpion is seldom fatal.

The little false-scorpions (*Chelifer*, Fig. 138) often occur in books, under the bark of trees, and under stones. The whip-scorpion is confined to warm countries; *Thelyphonus giganteus* occurs in New Mexico and Mexico. Its abdomen ends in a long lash-like appendage. Its bite is poisonous. The harvest-men, or daddy-long-legs, are common

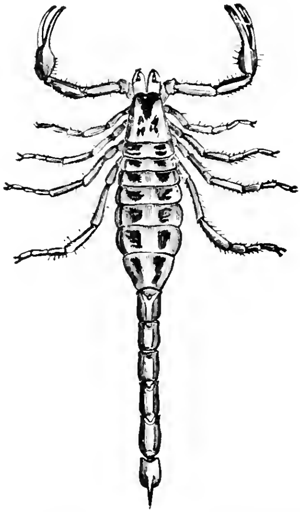


FIG. 137.—Carolina Scorpion (*Buthus Carolinianus*). Natural size.

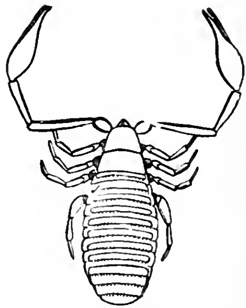


FIG. 138.—*Chelifer cancroides.* Magnified.

in dark places about houses. They feed on plant-lice. Our common species is *Phalangium dorsatum.*

Order 3. *Araneina.*—The spiders are always recognizable by their round abdomen, attached by a slender pedicel to the head-thorax. They breathe, like the scorpions, both by lungs as well as by tracheæ, and the young resemble the parents in having four pairs of feet. The mandibles end in hollow points, through which the poison exudes, the two poison-glands being situated in the head.

The male spider is usually much smaller than the female; the latter lay their eggs in silken cocoons. The tarantula (*Lycosa*) usually lives in holes in the ground, and sometimes conceals the opening by covering it with a few dead leaves. The common garden spider is *Epeira vulgaris*.

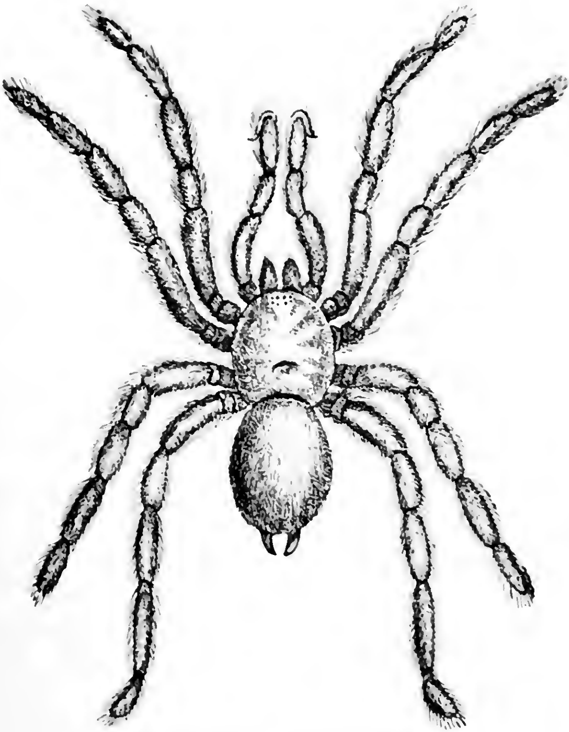


FIG. 139.—*Mygale*. Trap-door Spider.

It lives about houses and in gardens; its geometrical web is very regular. The large trap-door spider (*Mygale*) has four lung-sacs instead of two, as in the other spiders, and only two pairs of spinnerets. *Mygale Hentzii* (Fig. 139) inhabits the Western plains and Utah; the gigantic

Mygale avicularia of South America is known to seize small birds and suck their blood. There are probably about eight hundred species of spiders in North America; their colors are often brilliant, and sometimes, from the harmony in their coloration with that of the flowers in which they hide or the leaves on which they may rest, elude the sight of insectivorous birds. John Burroughs, in his "Pepacton," says that one sunny April day his "attention was attracted by a soft, uncertain purring sound" made by little spiders travelling about over the leaves.

Class VI.—Insecta.

General Characters of Insects.—Winged insects have a separate head, thorax, and abdomen. They have compound as well as simple eyes, two pairs of wings, and three pairs of thoracic legs. There are sixteen orders.

Orders of Insects.

1. Wingless, often with a spring. *Thysanura:* Spring-tails, etc.
2. Fore wings minute, elytra like. *Dermaptera:* Earwig.
3. Wings net-veined; fore wings narrow; hind wings folded.. *Orthoptera:* Locusts, Grasshoppers.
4. Four net-veined wings; mouth-parts adapted for biting..... *Platyptera:* White Ants, Bird-lice.
5. Wings net-veined, equal...... *Odonata:* Dragon-flies.
6. Wings net-veined, unequal.... *Plectoptera:* May flies.
7. Mouth beak-like, but with palpi *Thysanoptera:* Thrips.
8. Mouth-parts forming a beak for sucking; no palpi....... *Hemiptera:* Bugs.
9. Wings net-veined; metamorphosis complete............ *Neuroptera:* Lace-winged Fly, etc.
10. Wings long and narrow...... *Mecoptera:* Panorpa.
11. Wings not net-veined......... *Trichoptera:* Caddis-fly.
12. Fore wings sheathing the hinder ones.................... *Coleoptera:* Beetles.
13. Wingless, parasitic........... *Siphonaptera:* Flea.
14. One pair of wings............ *Diptera:* Flies.
15. Four wings and body scaled.. *Lepidoptera:* Butterflies.
16. Four clear wings; hinder pair small; a tongue .... *Hymenoptera:* Bees, Wasps, etc.

Order **1.** *Thysanura.*—The spring-tails (*Podura*) and *Smynthurus* (Fig. 140) and bristle-tails (*Lepisma*) are examples of this order. The Podurans have a peculiar forked appendage in the end of the body, which is held in place by a hook; when set free the spring darts backward, throwing the minute insect high in the air.

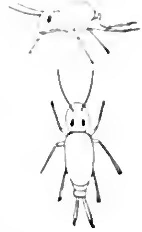


FIG. 140.—*Smynthurus*, a spring-tail. Magnified.

Order 2. *Dermaptera.*—The earwig (*Forficula*) is the representative of this small group, which is characterized by the small, short, elytra-like fore wings, and the large peculiar hind wings, while the body ends in a forceps-like appendage.

Order 3. *Orthoptera.*—Locusts, grasshoppers, crickets, etc., are called Orthoptera (straight-wings) from their narrow, straight, fore wings; the broad hinder pair being folded fan-like under the fore pair.

Many Orthoptera, as the crickets, green grasshoppers,

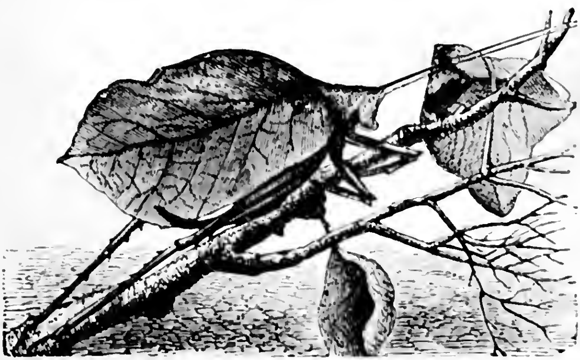


FIG. 141.—A Katydid-like form resembling a leaf.

katydids (Fig. 141), etc., and locusts (Fig. 142), produce loud, shrill sounds. The sound is made in three ways, *i.e.*, first, by rubbing the base of one wing-cover on the other (crickets and green grasshoppers): second, by rubbing the inner surface of the hind legs against the outer surface of the front wings (some locusts); third, by rubbing together

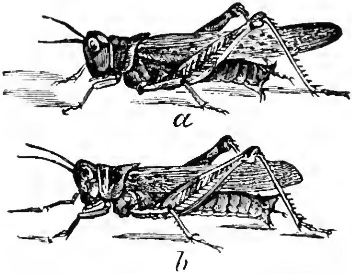


FIG. 142.—Rocky Mountain Locust; *b*, Red-legged Locust.

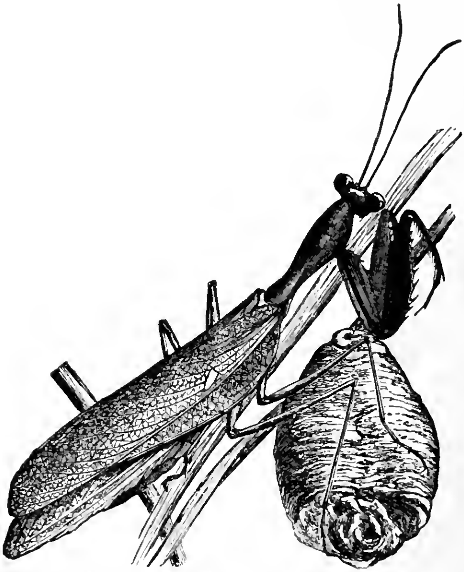


FIG. 143.—An African *Mantis*, or soothsayer, with its egg-mass.

the upper surface of the front edge of the hind wings and the under surface of the wing-covers during flight (some locusts).

Other examples of Orthoptera are Mantis (Fig. 143), the curious leaf insect (Fig. 144), and the stick insect (Fig. 145).

FIG. 144.—Leaf insect (*Phylium*). Half natural size.

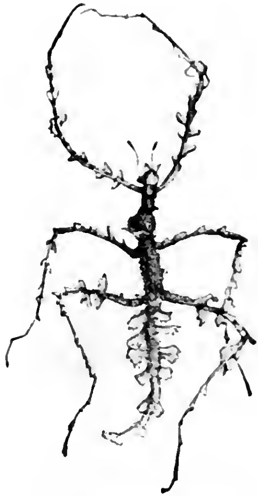


FIG. 145.—Stick insect.

Order 4. *Platyptera.*—The white ants live in stumps and fallen trees, and in the tropics do much harm by un-

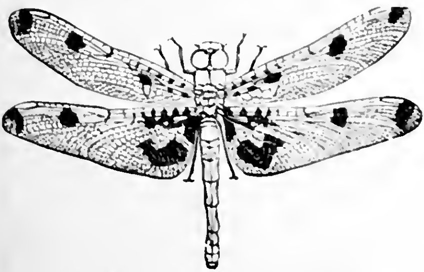


FIG. 146.—Dragon-fly (*Diplax Elisa*).

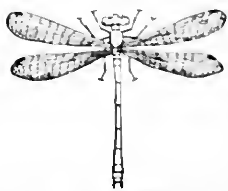


FIG. 147.—*Agrion*. Nat. size.

dermining the timbers of houses, and destroying furniture, books, etc. Their colonies are very populous. In our white ant there are, besides males and females, workers and soldiers, the latter with large heads and long jaws. The white ants in Africa build conical hills six feet or more in height.

Order 5. *Odonata.*—Dragon-flies (Figs. 146, 147) represent this order. They have broad, net-veined wings and free biting mouth-parts. The metamorphosis is incomplete, the pupæ (Fig. 148) being active and feeding on smaller insects, only differing from the larvæ in having rudiments

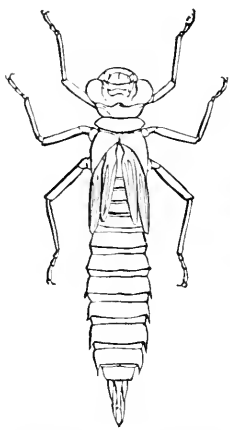


FIG. 148.—Pupa of a Dragon-fly (*Æschna*).

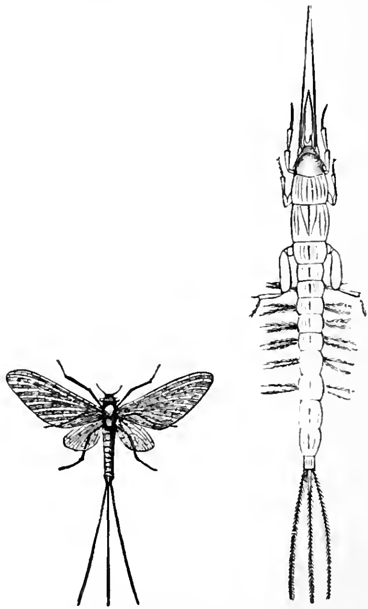


FIG. 149.—May-fly and larva, the latter enlarged.

of wings. Dragon-flies are constantly on the wing in pursuit of insects; they are sometimes called "mosquito hawks."

Order 6. *Plectoptera.*—May-flies (Fig. 149) are so called from their shortness of life, as they live but a day or two. The young live in the water, and breathe by feathery gills on the side of the body.

Order 7. *Thysanoptera.*—*Thrips* and its allies were referred by Haliday to a distinct order. The mouth-parts form a sort of beak; the mandibles are bristle-like; the maxillæ flat, triangular, bearing two- to three-jointed palpi; the labial palpi are very short, two- to three-jointed. The wings are small, long and narrow, fringed; both pairs of equal size, usually without veins. The antennæ are five- to nine-jointed.

Thrips.

Order 8. *Hemiptera.*—The bugs (Fig. 150) have a long beak bent on the breast. They suck the juices of plants and blood of insects. The chinch-bug (Fig. 151) is fearfully destructive in certain years to corn and wheat; collecting under the base of the leaves in great numbers, it sucks the sap and kills the plant.

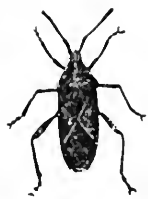


FIG. 150. — *Coreus*, Squash-bug. Natural size.

While most insects live but one and some live two years, the seventeen-year Cicada (Fig. 152) lives over sixteen years as a larva, becoming a pupa and finally acquiring wings in the seventeenth year.

The Aphis or plant-louse (Fig. 153) is provided with two tubes on the end of the body from which

FIG. 151.—Chinch-bug. *a*, *b*, eggs; *c*, *c*, larva; *f*, *g*, pupa; *i*, beak.

"honey dew" drops, which attracts ants, wasps, etc. In summer the female plant-lice bring forth young alive, and as there may be nine or ten generations, one virgin Aphis may become the parent of millions of children and grand-children.

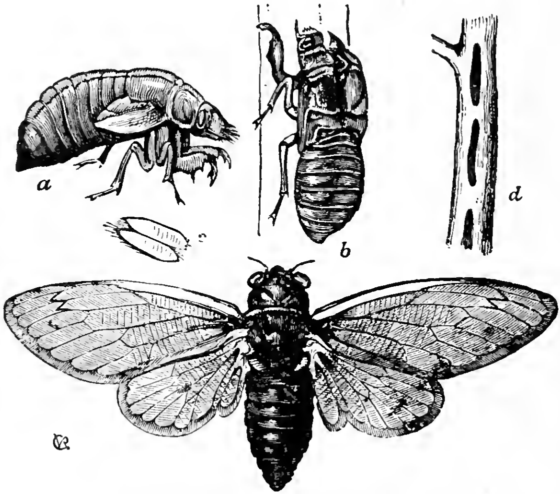


FIG. 152.—Seventeen-year Cicada. *a*, *b*, pupa; *c*, *d*, eggs.

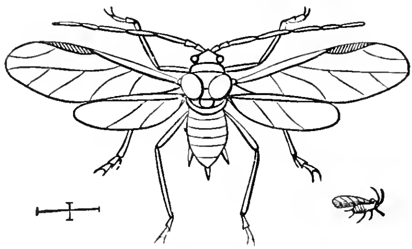


FIG. 153.—Apple Aphis. Natural size and enlarged.

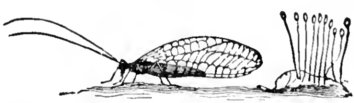


FIG. 154.—*Chrysopa* and group of stalked eggs.

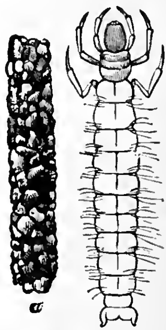


FIG. 155.—Case-worm. *a*, case.

Order 9. *Neuroptera*.—These are net-veined insects with a complete metamorphosis, the chrysalis residing in a cocoon. Such are the lace-winged fly (Fig. 154), the ant-lion, and *Corydalus*. The aphis-lion is the larva of the lace-winged fly, and devours large numbers of plant-lice.

Order 10. *Mecoptera.*—The type of this group is *Panorpa*.

Order 11. *Trichoptera.*—The case-worms are the larvæ of moth-like insects called Caddis-flies. Their wings are veined much as in the smaller moths. Their larvæ resemble caterpillars, but live in water, in cases (Fig. 155).

Order 12. *Coleoptera.*—In beetles the fore-wings are thickened, not used in flight, and form sheaths (*elytra*), which

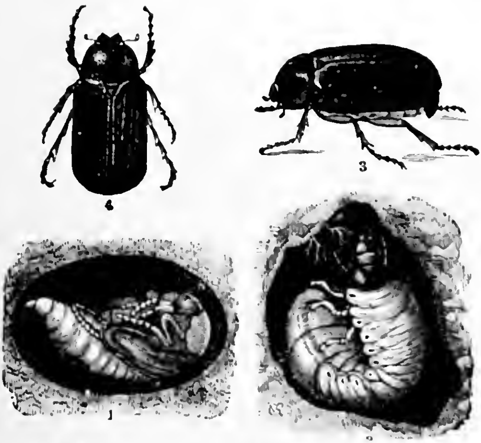


FIG. 156.—Metamorphosis of the May-beetle; 2, larva; 1, pupa.

protect the under or hinder pair. Their young are called grubs; the pupæ usually rest in cocoons of earth, etc., their metamorphosis being complete (Fig. 156). The tiger and ground beetles have long sharp jaws for seizing other insects; they are the tigers of the insect world. The burying-beetles are scavengers, and useful insects they are. The leaf-beetles are very numerous, and comprise as in the potato-beetles (Fig. 157) some of our most destructive insects. Injurious to trees and fruit are the boring-beetles and the weevils. The latter with their long beak, at the end of which are the thick powerful jaws, bore into nuts and seeds or fruit. Such are the plum-weevil (Fig. 158),

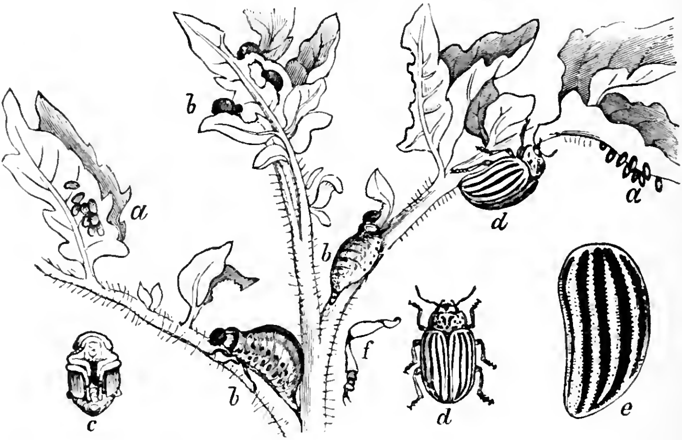


FIG. 157.—Colorado potato-beetle; *a*, eggs; *b*, *b*, *b*, larva; *c*, pupa; *d*, beetle; *e*, a wing-cover.

and the chestnut, acorn, and hickory-nut weevils. These weevils when disturbed instantly feign death; and they also

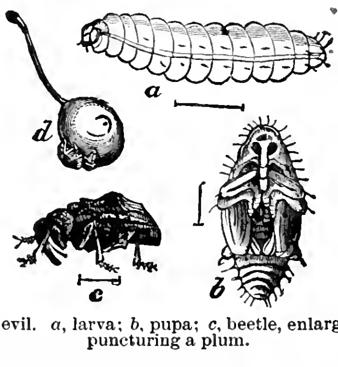


FIG. 158.—Plum Weevil. *a*, larva; *b*, pupa; *c*, beetle, enlarged; *d*, natural size, puncturing a plum.

escape the attacks of the ever-watchful birds by their resemblance to buds. A few beetles are beautifully phosphorescent. Such are the fire-flies, the cucuyo of the West Indies, and the glow-worm.

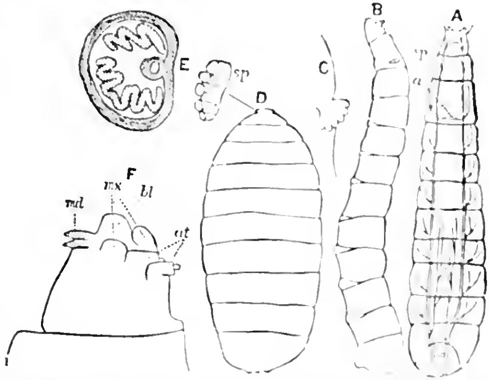


FIG. 159.—The early stages of the common House-fly. *A*, **dorsal and** *B*, **side view of the larva;** *a*, **air-tubes;** *sp*, **spiracle.** *C*, **the spiracle enlarged.** *F*, **head of the same larva, enlarged;** *bl*, **labrum (?);** *md*, **mandibles;** *mx*, **maxillæ;** *at*, **antennæ.** *E*, **a terminal spiracle much enlarged.** *D*, **puparium;** *sp*, **spiracle. All the figures much enlarged.**

Order 13. *Siphonaptera.*—Fleas represent this group.

Order 14. *Diptera.*—The common house-fly (Fig. 159) is a type of this group, all the members of which have but

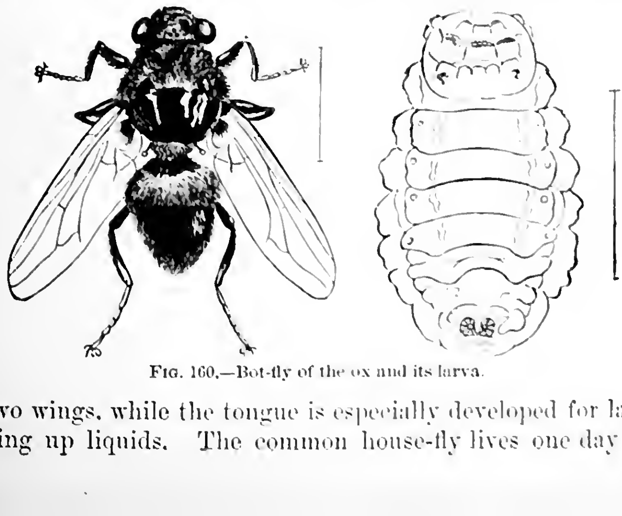


FIG. 160.—Bot-fly of the ox and its larva.

two wings, while the tongue is especially developed for lapping up liquids. The common house-fly lives one day in the egg state, from five days to a week as a maggot, and from five to seven days in the pupa state. It breeds about stables.

The Tachina-fly is beneficial to man, from its parasitism in the bodies of caterpillars and other injurious insects.

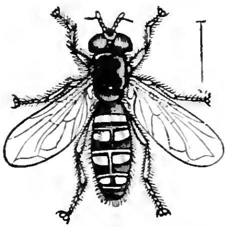


FIG. 161.—*Syrphus politus* Say.

The bot-fly (Fig. 160, *Hypoderma bovis*) is closely allied to the house-fly, but the maggot is much larger. The larval bot-fly of the horse lives in the stomach; that of the sheep in the frontal sinus, a cavity in the forehead.

The Syrphus flies (Fig. 161, *Syrphus politus*) mimic wasps; their maggots are most useful in devouring aphides.

The fleas are wingless flies, allied to winged forms which are intermediate between the house-flies and crane-flies.

In the two-winged gall-flies (*Cecidomyia*, etc., Fig. 162, *C. tritici*, Hessian-fly) the body is small and slender, with long antennæ. The crane-flies (*Tipula*) are large flies, standing near the head of the order, and, like the flea and

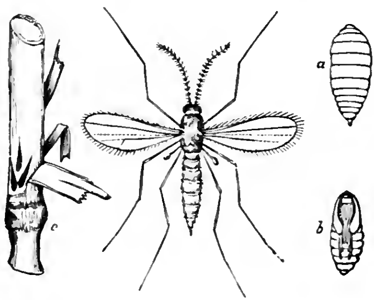


FIG. 162.—Hessian-fly. *a*, larva; *b*, pupa; *c*, incision in wheat-stalk for larva.

gall-fly, the chrysalis is enclosed in a cocoon, there being no *puparium* or pupa-case. as in the lower flies. Lastly, we have the mosquito (Figs. 163, 164), whose larva is aquatic, and breathes by a process on the end of the body, containing an air-tube.

Order 15. *Lepidoptera.*—The butterflies and moths are known by their scaly bodies, the spiral maxillæ or tongue

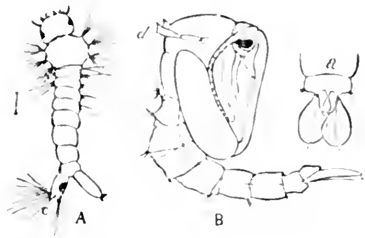


FIG. 163.—*A*, larva; *c*, its respiratory tube. *B*, pupa; *d*, respiratory tube. *a*, two paddles at the end of the body.

rolled up between the two large labial palpi, and by their usually broad scaly wings.

The larger moths are represented by the canker-worm, the grass army-worm and the cotton army-worm (Fig. 165).

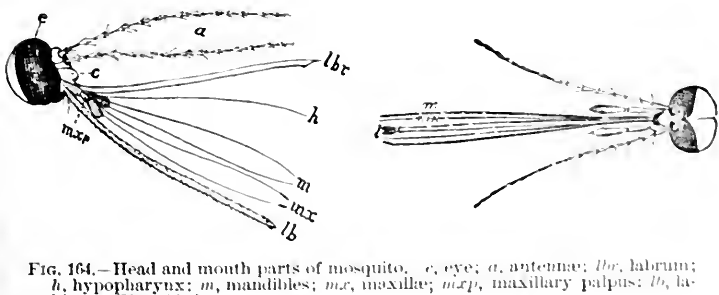


FIG. 164.—Head and mouth parts of mosquito. *e*, eye; *a*, antennæ; *lbr*, labrum; *h*, hypopharynx; *m*, mandibles; *mx*, maxillæ; *mxp*, maxillary palpus; *lb*, labium. (Magnified.)

so destructive to vegetation; the silk-worm moth (*Bombyx mori*) of the Old World, and the American silk-worm (*Telea Polyphemus*).

The hawk-moths (*Sphinx*) are distinguished by their large size and very long tongue. The butterflies differ from the moths in having knobbed antennæ, while their chrysalides are often ornamented with golden or silvery spots.

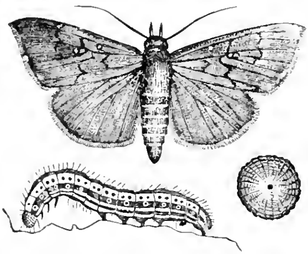


FIG. 165.—Egg, caterpillar, and moth of *Anomis xylina*, the Cotton Army-worm.

Order 16. *Hymenoptera.*—The bees stand at the head of the insect series in perfection of parts, especially those of the mouth.

The *Hymenoptera* are represented by the saw-flies, the gall-flies, the ichneumon-flies and the ants, the sand-wasps, mud-wasps, paper-making wasps, and bees.

The lowest family is the *Uroceridæ*, or horn-tails (Fig.

FIG. 166.—Horn-tail: larva of *Tremex columba*. Nat. size.

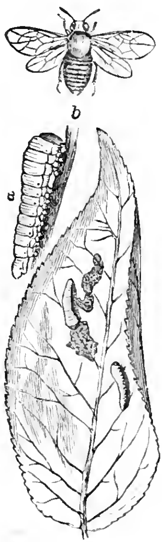


FIG. 167.—Pear Slug, natural size, gnawing leaves. *a*, larva enlarged; *b*, the fly.

FIG. 168.—Gall-fly of oak.

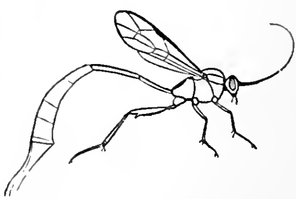


FIG. 169.—An Ichneumon-fly.

166, larva of *Tremex columba*), whose fleshy white larvæ bore in trees. The adults are large, with a long, saw-like ovipositor. In the saw-flies (*Tenthredinidæ*, Fig. 167 the pear-slug, *Selandria cerasi*) the larva strongly resembles a caterpillar, having eight pairs of abdominal feet.

The gall-flies (Fig. 168, *Cynips*) are small Hymenoptera which lay eggs in the leaves or stems of the oak, etc.,

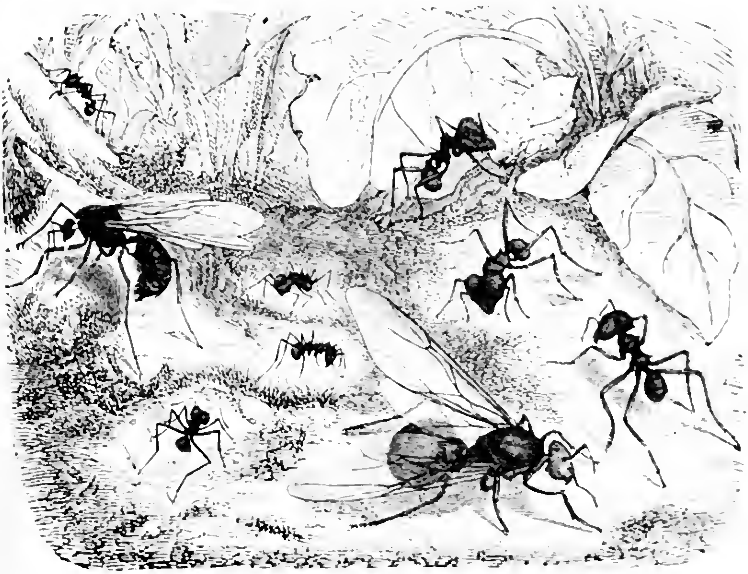


FIG. 170.—Œcodoma, or Leaf cutter Ant of Nicaragua

which, from the irritation set up by their presence, causes the swelling termed a gall.

The ichneumon-flies (Fig. 169) are very numerous in species and individuals; by their ovipositor, often very long, they pierce the bodies of caterpillars, inserting several or many eggs into them; the larvæ feed only on the fatty tissues of their host, but this usually causes the death of the caterpillar before its transformation.

The family of ants is remarkable for the complexity of the colony, the division of labor and the reasoning powers manifested by the workers and soldiers, which, with the males and females, constitute the ant-colony.

Certain ants enslave other species; have herds of cattle, the aphides; build complicated nests or formicaries, tunnel broad rivers, lay up seeds for use in the winter-time, are patterns of industry, and exhibit a readiness in overcoming extraordinary emergencies, which show that they have sufficient reasoning powers to meet the exigencies of their life; their ordinary acts being instinctive—namely, the results of inherited habits. The leaf-cutter ants of Central and South America (Fig. 170) are famous from their leaf-cutting habits; the soldiers have large triangular heads, while the workers have much smaller rounded heads.

FIG. 171.—Mud-dauber.

The mud-daubers (*Pelopæus,* Fig. 171) build their nests

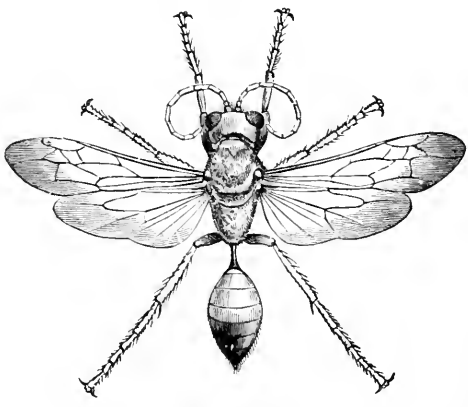


FIG. 172.—Sand-wasp (*Sphex*). Natural size.

against stone walls, of pellets of mud, while the sand- and mud-wasps dig deep holes (Fig. 172, *Sphex ichneumonea*) in gravelly walks, and have the instinct to sting grasshoppers in one of the thoracic nerve-centres, thus paralyzing the victim, in which the wasp lays her eggs; the young hatching, feed upon the living but paralyzed grasshoppers, the store of living food not being exhausted until the larval wasp is ready to stop eating and finish its transformations.

The genuine paper-making wasps are numerous in species; here the workers are winged, and differ from the females or queens in being rather smaller. *Odynerus* builds cells of mud. The genuine paper-making wasps, such as *Vespa*, build several tiers of cells, arranged mouth downward, and enveloped by a wall of several thicknesses of paper. In the *Vespæ*, the females found the colony, and raise a brood of workers, which early in the summer assist the queen in completing the nest.

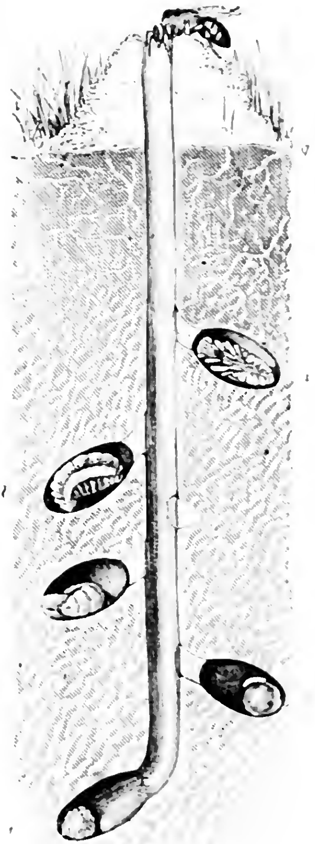


FIG 173.—Nest of Andrena. *g*, level of ground; *a*, first-made cell, containing a pupa; *b*, *l*, larvæ; *e*, pollen mass with an egg laid on it; *f*, pollen mass freshly deposited by the bee.

The bees also present a gradual series from those which are solitary, living in holes in the earth, like the ants (Fig. 173), and forming silk-lined earthen cocoons, to those which are social, with winged workers, slightly differing from the queens. The queen humble-bee hibernates, and in the spring founds her colony by laying up pellets of pollen in some subterranean mouse-nest or in a stump, and the young hatching, gradually eat the pollen, and when it is exhausted and they are fully fed, they spin an oval cylindrical cocoon; the first brood are workers, the second males and females. The partly hexagonal cells of the stingless bees of the tropics (*Melipona*) are built by the bees, while the hexagonal cells of the honey-bee are made by the bees from wax secreted by minute glands in the abdomen. Though the cells are hexagonal, they are not built with mathematical exactitude, the sides not always being of the same length and thickness.

The cells made for the young or larval drones are larger than those of the workers, and the single queen-cell is large and irregularly slipper-shaped. Drone-eggs are supposed not to be fertilized. Certain worker-eggs have been known to transform into queen-bees. On the other hand, worker-bees may lay drone-eggs. The maximum longevity of a worker is eight months, while some queens have been known to live five years. The latter will often, under favorable circumstances, lay from 2000 to 3000 eggs a day. The first brood of workers live about six weeks in summer, and are succeeded by a second brood.

LITERATURE OF ARTHROPODA. (For Crustacea see p. 85.)

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CHAPTER VIII.

BRANCH VIII.—VERTEBRATA (*Back-boned Animals*).

GENERAL CHARACTERS OF VERTEBRATES.—We have seen that most of the foregoing types of animals have the body protected by a crust or shell, enclosing the muscles and other internal organs; but now we come to animals which have an internal bony support or skeleton. The skeleton consists of a backbone (Fig. 174) with bones forming a skull and a series of bones supporting the limbs. Fishes, reptiles, birds, and mammals or beasts, are familiar examples of vertebrates, while man himself is a vertebrate. Vertebrates in general have bodies which are symmetrical, *i.e.*, the two sides repeat each other; they have a brain-box or skull containing the brain and the mouth and pharynx, with two eyes, two ears, and usually two nasal openings. To the trunk are attached two pairs of limbs; the forearms in man corresponding to the fore legs of the horse or dog.

Now if we cut a fish in two, and closely examine the section, we shall notice that above the backbone is a little cavity containing the nervous cord, and below a much larger cavity containing the *viscera*, *i.e.*, heart, liver, stomach or intestine. Thus there are two cavities, the nervous one above, and the visceral one below the backbone (Figs. 175, 176). In this respect the backboned animals differ from the backboneless or invertebrate animals, in which there is but one body-cavity, with the nervous system situated on the floor of this cavity.

Vertebrates have a true heart, with one, generally two, auricles, and one or two ventricles, and, besides arteries and

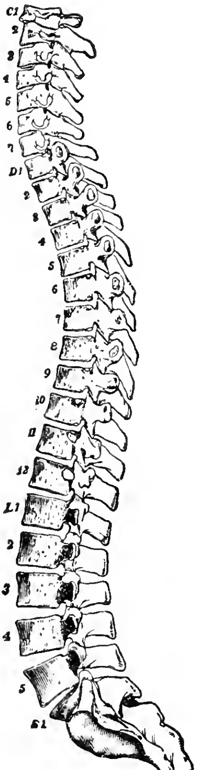

FIG. 174.—Side view of the vertebral column or back-bone of man. From Martin.

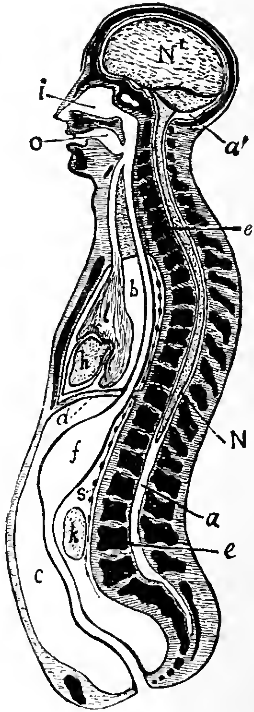

FIG. 175.—Diagrammatic longitudinal section of the body. *a*, the neural tube, with its upper enlargement in the skull cavity at *a'*; *N*, the spinal cord; *N'*, the brain; *ee*, vertebræ forming the solid partition between the dorsal and ventral cavities; *b*, the pleural, and *c*, the abdominal divisions of the ventral cavity, separated from one another by the diaphragm, *d*; *i*, the nasal, and *o*, the mouth chamber, opening behind into the pharynx, from which one tube leads to the lungs, *l*, and another to the stomach, *f*; *h*, the heart; *k*, a kidney; *s*, the sympathetic nervous chain. From the stomach, *f*, the intestinal tube leads through the abdominal cavity to the posterior opening of the alimentary canal.

veins, a system of capillary vessels, which are minute tubes connecting the ends of the smaller arteries with the smaller veins. There are no genuine capillaries in the lower animals exactly comparable with those of vertebrates.

The blood is red in all the vertebrates except the lancelet, and besides white corpuscles contains red corpuscles. While fishes and tadpoles breathe by gills, all land and amphibious vertebrates breathe the air directly by lungs connected by a windpipe (*trachea*) with the mouth. The nervous system consists of a brain and spinal cord. The brain consists of four pairs of lobes, *i.e.*, the olfactory

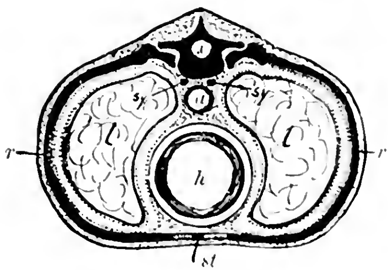

FIG 176.—A diagrammatic section across the body in the chest region. *x*, the dorsal tube, which contains the spinal cord; the black mass surrounding it is a vertebra; *a*, the gullet, a part of the alimentary canal; *h*, the heart; *sy*, sympathetic nervous system; *ll*, lungs; the dotted lines around them are the pleuræ; *r r*, ribs; *st*, the breastbone. From Martin.

lobes, cerebral hemispheres, the optic thalami with the pineal gland, and the optic lobes; besides these lobes, which are arranged in pairs, there are two single parts of the brain, the cerebellum and the beginning of the spinal cord, called the *medulla oblongata*.

The limbs each consist of a single long bone, succeeded by two long bones, followed by two transverse rows of short wrist or ankle bones, and five series of long finger or toe bones called phalanges. For example, in the fore limb of most vertebrates, as in the arm of man, to the shoulder girdle is articulated the *humerus*; this is succeeded by the *ulna* and *radius;* these by the wrist-bones or carpals, and the finger-bones or *phalanges*, the single row of phalanges forming the digit (finger or toe). To the pelvis are attached the hind limbs, consisting each of a *femur* or thigh, which is succeeded by the *tibia* and *fibula* (shank-bones), which are followed by the tarsal and metatarsal bones (ankle-bones), and by the phalanges or bones forming the toes.

Classes of Vertebrates.

1. Young with a nervous and dorsal cord .... *Tunicata.*
2. No skull or brain; blood colorless............... *Leptocardii.*
3. Notocord persistent; no jaw-bones; six to ten pairs of purse like gills........................... *Marsipobranchii.*
4. Swimming by fins; with gills; a movable under jaw... *Pisces.*
5. Amphibious; true limbs and lungs; skin smooth, no scales, no claws........................... *Batrachia.*
6. Claws and scales present .... *Reptilia.*
7. Body covered with feathers; fore-limbs forming wings.................. .... *Aves.*
8. Body covered with hair; suckling their young... *Mammalia.*

Class I.—Tunicata (*Ascidians, Sea-squirts*).

General Characters of Tunicates.—While the Tunicates were formerly supposed by some to be mollusks, and by others worms, they have been found to possess in the larval stage a notocord, above which lies a rudimentary brain, with a spinal cord, and even spinal nerves. A tadpole-like form (*Appendicularia*) retains the fundamental vertebrate features we have just noticed, while all other Ascidians which undergo a metamorphosis lose their tails, notocord, and nervous cord, and degenerate into ordinary Ascidians.

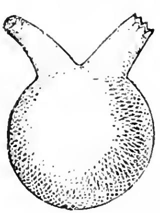

Fig. 177.—Molgula. An Ascidian.

The Ascidians are common just below low-water mark, either hidden in masses of mussels, attached to the rocks under sea-weeds, or the compound species may be found forming bright-colored masses on the piles of wharves and bridges, while the star-like *Botryllus* grows on the leaves of eel-grass. On placing a good-sized Ascidian in a vessel of fresh sea-water it will be found to consist of a semi-transparent or quite opaque test with two openings, one lower than the other, as seen in *Molgula*, which looks, when the two orifices are protruded, like a double-necked bottle (Fig. 177). The anterior or higher orifice or mouth is for the passage of currents of water into the respiratory sac; and the posterior, usually lower, excurrent orifice for the passage outwards of fecal matter. The test or outer skin is either delicate and semi-transparent, or it may be quite tough and opaque.

Fig. 178.—Structure of a compound Ascidian, *Amaroecium*. *A*, branchial sac; *m*, stomach; *h*, intestine; *c*, mouth; *o*, testis; *rr*, efferent duct of the testis; *C*, ovary; *p*, egg in the body-cavity; *p'*, eggs in the atrium; *n*, anus; *o* shows the site of the heart; *l*, liver; *e*, openings in walls of branchial chamber.

The Tunicates may in general terms be characterized as having a usually rounded or sac-like body, which is sometimes barrel-shaped, bilateral, with a dorsal and ventral symmetry, protected by a transparent or dense test, containing cellulose, lined within by a tunic surrounding the body-cavity. There are two openings in the test, one oral, the other "atrial;" the mouth leads into a capacious pharyngeal respiratory sac, opening posteriorly by an œsophagus into the stomach, which is provided with a liver; the intestine is flexed, and ends near the œsophagus. The nervous system is bilateral, forming a double ganglionated chain in Appendicularia, but is reduced in the typical Ascidians to a single ganglion, situated within the tunic between the two openings. There is a tubular heart, opening at each end, and its beatings are often reversed, the blood flowing in and out at either end.

A singular group of Tunicates is represented by Salpa, which is a pelagic form, There are in Salpa two kinds of individuals, i.e., the solitary and the aggregated or chain Salpæ.

The young of many Ascidians are born with a tadpole-shape, in which there is a notocord, which, however, does not extend to the brain, and the mouth-opening is dorsal rather than ventral (Fig. 180), otherwise the larval Ascidian is strikingly like the embryo lamprey: in both, the

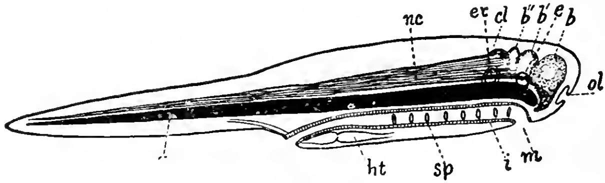

Fig. 179.—Diagram of embryo Lamprey.

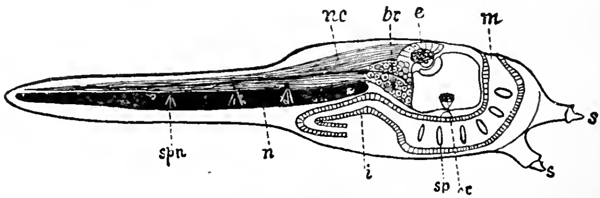

Fig. 180.—Diagram of larval Ascidian. Lettering as in Fig. 179. *m*, mouth; *i*, digestive tract; *sp*, spiracles in the pharyngeal portion; *ht*, heart; *e*, eye; *er*, ear; *br*, brain; *nc*, nervous cord; *b'*, *b''*, mid brain; *cl*, cerebellum; *spn*, spinal nerves; *n*, notocord; *ol*, nasal cavity; *s*, suckers (their homologues also occur in young gar-pikes and tadpoles).

mouth leads into a pharynx with gill-openings; both have a rudimentary brain, and a notocord situated beneath the nervous cord. The young Ascidian, then, is seen to have the fundamental characters ascribed to the vertebrates, though it loses them before growing up.

Class II.—Leptocardii (*Lancelet*).

The lancelet is the only type of this class. The body is four or five centimetres in length, slender, compressed, pointed at each end. The muscular segments are distinct to the naked eye. From the mouth to the vent is a deep ventral furrow, and a slight fin extends along the back and ventrally as far front as the vent.

The mouth is oval, surrounded with a circle of ciliated tentacles supported by semi-cartilaginous processes arising from a circumoral ring. The mouth leads directly into a large broad pharynx or "branchial sac" (Fig. 183, *g*), protected at the entrance by a number of minute ciliated lobes.

The walls of this sac are perforated by long ciliated slits, comparable with those of the branchial sacs of Ascidians and of *Balanoglossus*. The water which enters the mouth passes out through these slits where it oxygenates the blood, and enters the peribranchial cavity, thence passing out of the body through the abdominal pore (Fig. 183, *p*). The pharynx leads to the stomach (*f*), with which is connected the liver or cœcum. There is a pulsatile vessel or tubular

FIG. 183.—*a*, vent; *f*, stomach; *g*, pharynx; *n*, nervous cord; *p*, pore; *r*, notocord; *t*, tentacles. From Lütken's Zoology.

heart, beginning at the free end of the liver, and extending along the under side of the pharynx, sending branches to the sac and the two anterior branches to the dorsal aorta. "On the dorsal side of the pharynx the blood is poured by the two anterior trunks, and by the branchial veins which carry away the aërated blood from the branchial bars, into a great longitudinal trunk or dorsal aorta, by which it is distributed throughout the body." (Huxley.) There are also vessels distributed to the liver, and returning vessels, representing the portal and hepatic veins. The blood-corpuscles are white and nucleated.

The vertebral column is represented by a notocord which extends to the end of the head far in front of the nervous cord; and also by a series of small semi-cartilaginous bodies above the nervous system, and which are thought to represent either neural spines or fin-rays. The nervous cord lies over the notocord; it is not divided into a true brain * and spinal cord, but sends off a few nerves to the periphery, with nerves to the two minute eye-spots. There are no kidneys like those of the higher Vertebrates, but glandular bodies which may serve as such. The reproductive glands are square masses attached in a row on each side of the walls of the body-cavity. The eggs may pass out of the mouth or through the pore. Kowalevsky found the eggs issuing in May from the mouth of the female, and fertilized by spermatic particles likewise issuing from the mouth of the male. The eggs are very small, 0.105 millimetres in diameter. The eggs undergo total segmentation, leaving a segmentation-cavity which becomes the body-cavity.

The blastoderm now invaginates and the embryo swims about as a ciliated gastrula. The body is oval, and the germ does not differ much in appearance from a worm, star-fish, or ascidian in the same stage of growth. No vertebrate features are yet developed.

Soon the lively ciliated gastrula elongates, the alimentary tube arises from the primitive gastrula-cavity, while the edges of the flattened side of the body grow up as ridges which afterwards, as in all vertebrate embryos, grow over and enclose the spinal cord. When the germ is twenty-four hours old it assumes the form of a ciliated flattened cylinder, and now resembles an Ascidian embryo, there being a nerve-cavity, with an external opening, which afterwards closes. The notocord appears at this time.

In the next stage observed the adult characters had appeared, the mouth is formed, the first pair of gill-openings are seen, eleven additional pairs appearing. It thus appears that while the lancelet at one time in its life presents Ascidian features, yet, as Balfour states, "all the modes of development found in the higher Vertebrates are to be looked upon as modifications of that of Amphioxus."

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* Langerhans has figured an olfactory lobe; and all observers agree that a ventricle is present; thus there is a slight approximation to a brain.

CLASS III.—MARSIPOBRANCHII (*Lampreys, or Cyclostomi*).

General Characters of the Cyclostomatous Vertebrates.—In the hag-fish and lamprey, representatives of the jawless Vertebrates, the body is long and slender, cylindrical, the skin smooth, scaleless, with only a median dorsal and ventral fin (or in *Myxine* only a small lower median fin); the mouth is circular, and in the lampreys armed with numerous conical teeth. There is no bony skeleton; the spinal column is represented simply by a thick rod (dorsal cord, notocord) surrounded by a sheath. The skull is cartilaginous, not movable on the vertebral column; is very imperfectly developed, having no jaws, the hyo-mandibular bones and the hyoid arch existing in a very rudimentary state. The few teeth present in the hag-fish are confined to the palate and tongue; those of the lamprey are numerous, conical, and developed on the cartilages supporting the lips.

The nervous system is much as in the fishes, the brain with its olfactory, cerebral lobes, thalami, optic lobes, and medulla being developed, the cerebellum in Myxine blended with, in the lamprey free from the medulla. The digestive canal is straight, with no genuine stomach, but the liver is much as in higher Vertebrates. The respiratory organs are very peculiar, being purse-like cavities (whence the name *Marsipobranchii*), in the lamprey seven in number on each side of the pharynx, opening externally by small apertures; internally they connect with a long cavity lying under the œsophagus, and opening anteriorly into the mouth. The heart is like that of fishes, as are the kidneys. The eyes are minute, sunken in the head and under the skin in the hag (*Myxine*), but larger in the lamprey.

Another extraordinary feature in the class is the single nasal aperture, as opposed to the two occurring in all higher Vertebrates. The aperture leads to a sac, which in the *Myxine* communicates with the mouth (pharnyx), but in the lamprey forms a cul-de-sac.

The ovaries and male glands (the sexes being distinct) are unpaired plates suspended from the back-bone, and have no ducts, the eggs breaking through the walls of the ovary, falling into the abdominal cavity and passing out of the abdominal pore. The eggs of *Myxine* are very large in proportion to the fish, enclosed in a horny shell, with a filament at each end by which it may adhere to objects.

The hag-fish is about a foot long and an inch thick, with the head small, a median palatine tooth, and two comb-like rows of teeth on the tongue. There is a single gill-opening a long way behind the head; there are large mucous or slime-glands on the side of the body, for these fishes are very slimy. The hag lives at considerable depths in the sea; we have dredged one at 114 fathoms in soft deep mud off Cape Ann. It is often parasitic, attaching itself to the bodies of fish, and has been found to have made its way into the body-cavity of sturgeons and haddock.

The lamprey lives both in fresh and salt water. The eggs of the common lamprey, *Petromyzon marinus* (Linn.), are laid in early spring, the fish following the shad up the rivers, and spawning in fresh water, seeking the sea in autumn; small individuals, from five to seven inches long, have been seen by Dr. Abbott attached to the bellies of shad, sucking the eggs out of the oviducts.

The lamprey when six inches long is quite unlike the adult, being blind, the eyes being concealed by the skin; it is toothless, and has other peculiarities. It is so strangely unlike the adult that it was described as a different genus (*Ammocœtes*). *P. nigricans* Lesueur is smaller, and occurs in the lakes of New York and eastward. while *P. niger* Rafinesque is still smaller, and lives in the Western States.

Class IV.—Pisces (*Sharks, Rays, Sturgeons, Garpikes, and bony fishes*).

General Characters of Fishes.—We now come to vertebrates which have genuine jaw-bones and fins in pairs, and which, in short, are allied to the Batrachians, and through them with the reptiles, birds, and mammals. All the fishes agree in having a true skull, to which is attached a movable lower jaw. The brain is well developed and the blood is red. Fishes breathe by gills, which form four arches on

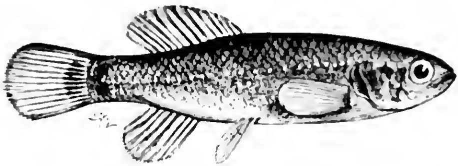


FIG. 181.—The Mud-Minnow, with the names of the fins.

each side of the throat. The body is usually scaled. They are mostly oviparous; some bring forth their young alive.

SUB CLASSES OF FISHES.

1. Skeleton cartilaginous; 5-7 pairs of gill-openings.................. *Elasmobranchii:* Sharks, Rays.
2. Skeleton cartilaginous or bony; scales often square, enamelled..*Ganoidei:* Sturgeon, Garpike.
3. Skeleton bony, of numerous separate bones; 4 pairs of gills......*Teleostei:* Cod, Perch, etc.

SUB-CLASS I.—ELASMOBRANCHII (*Selachians, or Sharks and Rays*).

These are called Elasmobranchs from the strap-like gill-openings (*elasma*, strap, and *branchia*, gill). The sharks, though fish-like, are very different from ordinary bony fish. Their skeleton or skull is so soft that it can be cut with a knife, while the tail is one-sided, the vertebral column ending in the larger upper lobe. They also have from five to seven gill-openings or slits, whereas the cod or perch has but one. The skin is either smooth, or with minute scales, forming *shagreen*. Both jaws are armed with numerous sharp, flattened teeth, arranged in rows and pointing backward, enabling them to seize and retain their prey.

Sharks and skates are engines of destruction, being the terror of the seas. Their entire structure is such as to enable them to seize, crush, tear, and rapidly digest large

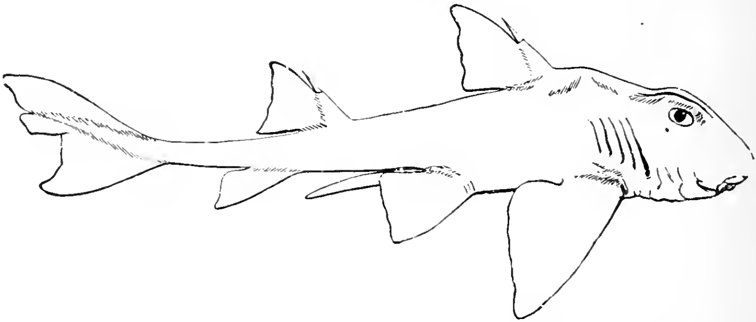


Fig. 185.—*Cestracion*, or Port Jackson Shark. From Lütken's Zoology.

fishes or other marine animals. Hence their own forms are gigantic, soft, not protected by scales or armor, as they have few enemies. Hence they do not need a high degree of intelligence, nor special means of defence or protection,

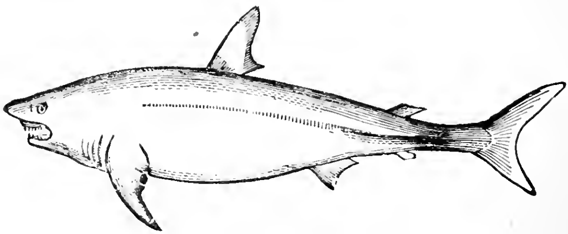


Fig. 186.—Mackerel Shark.

though from their activity the circulatory system is highly developed, the muscular aortic bulb being provided within with three rows of semi-lunar valves.

The eggs of sharks and rays are very large compared with those of bony fishes. The Cestracion (Fig. 185) is an old-fashioned form, which inhabits the Australian seas.

Order 1. *Plagiostomi.*—Our most common shark is the mackerel shark (*Isurus punctatus*, Fig. 186). It is from four to eight feet in length, and is often taken in fish-nets, being a surface-swimmer. In the thresher shark (*Alopecias vulpes*), the upper lobe of the tail is nearly as long as the body of the shark itself. It grows twelve or fifteen feet in length, and lives on the high seas of the Atlantic.

Nearly twice the size of the thresher is the great basking shark, *Selache maxima*, of the North Atlantic, which becomes nine to thirteen metres (thirty or forty feet) in length. It has very large gill-slits, and is by no means as ferocious as most sharks, since it lives on small fishes, and

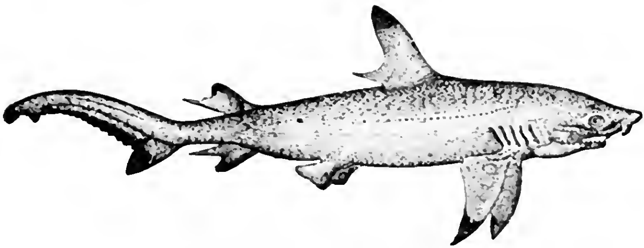


FIG. 187.—*Carcharias.* From Lütken's Zoology.

in part, probably, on small floating animals, straining them into its throat through a series of rays or fringes of an elastic, hard substance, but brittle when bent too much, and arranged like a comb along the gill-openings, the teeth being very small.

Among the smaller sharks is the dog-fish (*Squalus Americanus*), distinguished by the sharp spine in front of each of the two dorsal fins. It is caught in great numbers for the oil which is extracted from its liver. The dog-shark (*Mustelus canis*), which is a little larger than the dog-fish, becoming over a metre (four feet) long, brings forth its young alive.

The hammer-headed shark is so called from the head projecting far out on each side, the eyes being situated in the end of each projection.

It grows to the length of twelve feet, and is one of the most rapacious and formidable of sea-monsters. Among the largest sharks are the species of Carcharias (Fig. 187) One species frequents the Ganges, occurring sixty leagues from the sea.

Of the rays and skates, the saw-fish (*Pristis antïquorum*) approximates most to the sharks. Its snout is prolonged into a long, flat, bony blade, armed on each side with large teeth (Fig. 188). The common saw-fish inhabits the Mediterranean Sea and the Gulf of Mexico; it is viviparous (Caton). *Pristis Perroteli* lives in the Senegal River.

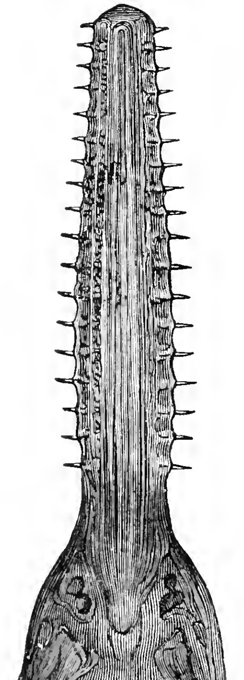


FIG. 188.—Beak of Saw-fish, seen from below, showing its mouth, nostrils, and lateral teeth.

The genuine skates or rays have the body broad and flat and rhomboidal, owing to the great extension of the thick pectoral fins. They swim close to the bottom, feeding upon shell-fish, crabs, etc., crushing them with their powerful flattened teeth. The smallest and most common skate of our northeastern Atlantic coast is *Raja erinacea*. It is one half of a metre (twenty inches) in length, and the males are smaller than the females. The largest species is the barndoor skate, *Raja lævis*, which is over a metre (forty-two inches) long. *Raja eglanteria* (Fig. 189) ranges from Cape Cod to the Caribbean Sea. The smaller figures in Fig. 189 represent respectively the mouth and gill-slits, and the jaws of *Myliobatis fremenvillii*.

In the torpedo the body is somewhat oval and rounded. Fig. 190 represents *Torpedo marmoratus* of the Mediterranean Sea.

Our native species, found mostly in winter, especially on the low sandy shores of Cape Cod is *Torpedo occidentalis*. Its batteries and nerves are substantially as in the European species. The electrical organs are constructed on the principle of a Voltaic pile, consisting of two series or layers

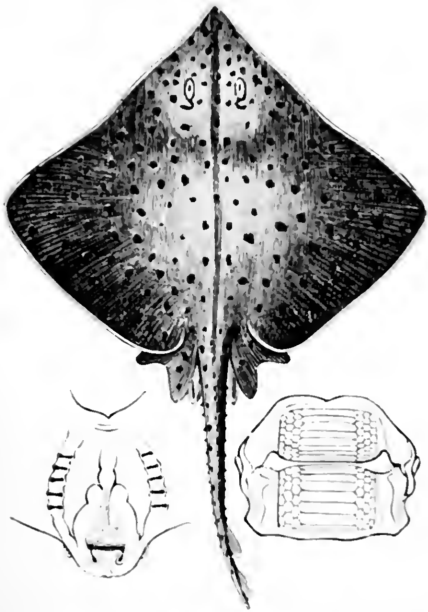


FIG. 189.—*Raja eglanteria*, male. Mouth and gill-slits, jaws and teeth of *Myliobatis fremenvillii*

of six-sided cells, the space between the numerous fine transverse plates in the cells filled with a trembling jelly-like mass, each cell representing, so to speak, a Leyden jar. There are about 470 cells in each battery, each provided with nerves sent off from the fifth and eighth pairs of nerves. The dorsal side of the apparatus is positively electrical, the ventral side negatively so. The electrical current passes from the dorsal to the ventral side. When the electrical ray is disturbed by the touch of any object, the impression is conveyed by the sensory nerves to the brain, exciting there an act of the will which is conveyed along

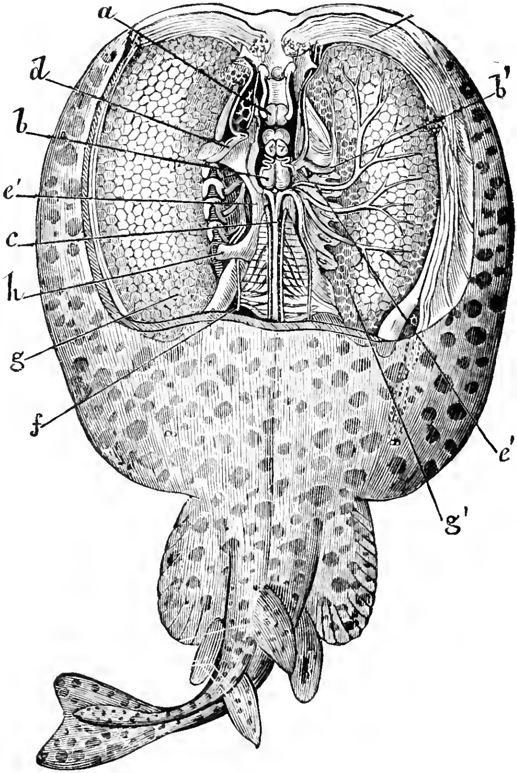


FIG. 190.—*Torpedo marmoratus.* *a*, brain; *b*, medulla oblongata; *c*, spinal cord; *d* and *b'*, electric portion of the trigeminate or fifth pair of nerves; *ee'*, electric portion of the pneumogastric or eighth pair of nerves; *f*, recurrent nerve; *g*, left electric organ entire; *g'*, right electric organ dissected to show the distribution of the nerves; *h*, the last of the branchial chambers; *i*, mucus-secreting tubes.

the electric nerves to the batteries, producing a shock. The benumbing power is lost by frequent exercise, being regained by rest; it is also increased by energetic circulation and respiration. As in muscular exertion the electrical power is increased by the action of strychnine.

Marey has more recently made interesting experiments on the torpedo, examining the discharge of this fish with the telephone. Slight excitations provoked a short croaking sound. Each of the small discharges was composed of a dozen fluxes and pulsations, lasting about one fifteenth of a second. The sound got from a prolonged discharge, however, continued three to four seconds, and consisted of

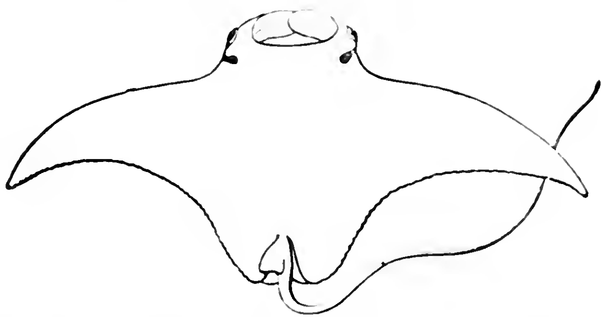


FIG. 191.—The Devil-fish. (*Ceratoptera*). From Lütken's Zoology.

a sort of groan, with tonality of about *mi* (165 vibrations), agreeing pretty closely with the result of graphic experiments.

Marey has also studied the resemblance of the electrical apparatus of the electrical ray or torpedo and a muscle. Both are subject to will, provided with nerves of centrifugal action, have a very similar chemical composition, and resemble each other in some points of structure. A muscle in contraction and in tetanus executes a number of successive small movements or shocks, and a like complexity has been proved by M. Marey in the discharge of the torpedo.

The sting-rays (*Trygon*) have no caudal fin, but the spinal column is greatly elongated, very slender, and armed with a long, erect spine or "sting." Some live in fresh water.

The devil-fish (*Cephalopterus diabolus*) of the coast of South Carolina and Florida is the largest of our rays, being eighteen feet across from tip to tip of its pectoral fins, and ten feet in length, weighing several tons. It sometimes seizes the anchors of small vessels by means of the curved processes of its head and swims rapidly out to sea, carrying

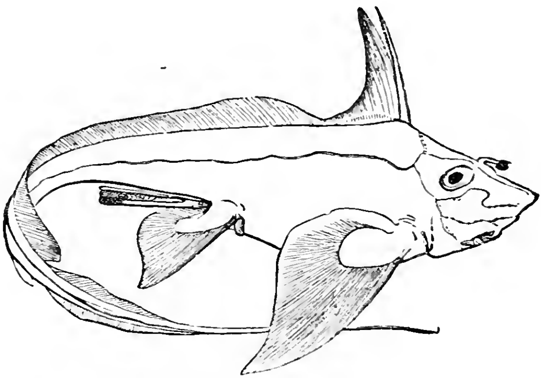


FIG. 192.—*Chimæra vulgaris.* From Lütken's Zoology.

the craft along with it. Closely allied to our devil-fish is the *Ceratoptera* (Fig. 191).

Order 2. Holocephali.—This small but interesting group of sharks is represented by the *Chimæra* (Fig. 192) of the North Atlantic, and *Callorhynchus* of the antarctic seas. In these fishes the four gill-openings are covered by a membrane, thus approaching the true bony fishes; there are but four teeth in the upper and two in the lower jaw.

SUB-CLASS II.—GANOIDEI (*Garpikes, Lung-fishes*).

The term Ganoid was applied to these fishes from the form of the scales, which in most of the species are angular, square, or rhomboidal, and covered with enamel, as seen in the common garpike. In others, however, as in the Amia and Dipnoans, the scales are rounded or *cycloid*. The sturgeons (Fig. 193) have the snout long and pointed, with the mouth underneath, and toothless, while the body is protected by very large scales. *Acipenser sturio* is the common sea-sturgeon of our coast, ascending rivers. The shovel-nosed sturgeon, *Scaphirhynchops platyrhynchus*, has a spade-like snout. It inhabits the waters of the Mississippi Valley.

The singular spoon-bill, *Polyodon folium* (Fig. 194), is five feet long, smooth-skinned, has a snout one third as long as the body, and spatulate, with thin edges. It has a very wide mouth, with minute teeth, and lives on small Crustacea. It abounds in the Mississippi and its larger tributaries.

The *Dipnoi* or lung-fishes are so-called from the fact that often being in pools and streams liable to dry up, they breathe air directly, having true lungs, like those of frogs, as well as gills. From the nature of their brain and 3-chambered heart, the Dipnoans are quite different from all other fishes, while on the other hand the notocord is persistent.

The body of the Dipnoans is somewhat eel-shaped, though not very long in proportion to its thick-

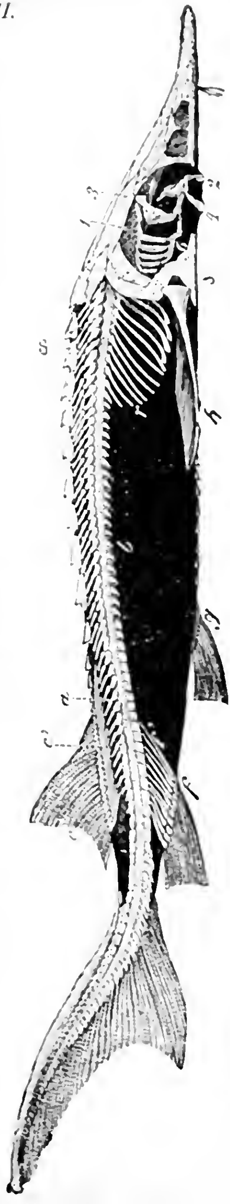


FIG. 193.—Sturgeon. 1, 8, shoulder arch; 6, gill arches; *a*, upper, *b*, lower spinous processes; *c*, dorsal fin; *c'*, processes supporting the fin; *e*, heterocercal caudal fin; *f*, anal fin; *g*, ventral; *h*, pectoral fin. From Lütken's Zoology.

ness, and is covered with round scales. The pectoral and ventral fins are long, narrow, and pointed, and the vertebral column extends to the end of the caudal fin, which ends in a point, not being two-lobed as in other fishes.

The Australian lung-fish (Fig. 195) has but a single lung, It attains a length of six feet. It can breathe either by gills or lungs alone. Ordinarily it uses its gills, but when the

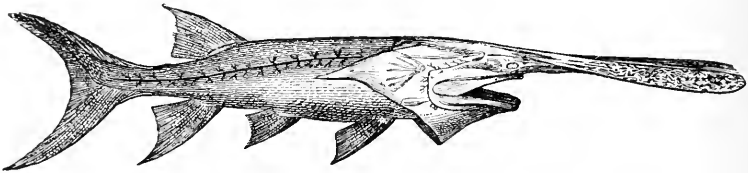


FIG. 194.—Spoon-bill fish. From Lütken's Zoology.

fish is compelled to live during droughts in thick muddy water charged with gases which are the product of decomposing organic matter, it is obliged to use its lungs. It lives on the dead leaves of aquatic grasses, etc. The local English name is "flat-head," the native name being "barramundi."

The African lung-fish (Fig. 196) has two lungs. It lives

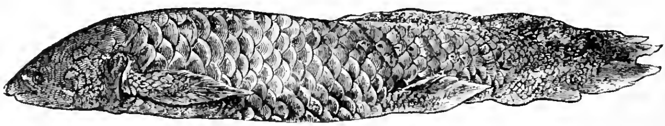


FIG. 195.—*Ceratodus*, or Australian Lung-fish. (The tail in nature ends in a point.)

on leaves in the White Nile, the Niger, and Gambia rivers, where it buries itself in the mud a foot deep. A similar lung-fish (*Lepidosiren*) lives in the rivers of Brazil, and the closely allied *Protopterus* in tropical Africa. *Ceratodus* makes use of the lungs mainly when the muddy water is saturated with gases from organic matter.

Finally we come to those American Ganoids whose skeleton is solid and bony. These are the garpikes and mud-fish.

The garpikes (Fig. 197) have large mouths and large, conical, sharp teeth, and the body is encased in an enamelled coat of mail. They are the terror of the Mississippi River and its branches, as they destroy all the smaller fish. The largest species is the alligator gar (*Lepidosteus spatula*),

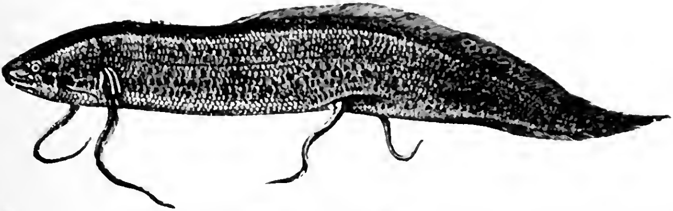


FIG. 196.—*Protopterus annectens*, a Lung-fish of Africa. One third natural size.

which is sometimes nearly three yards (three metres) in length, and sometimes weighing several hundred pounds. So hard is its armor, that a blow with an axe cannot penetrate its back, the only vulnerable point being its throat or the back of its head. It inhabits the lower Mississippi and the stagnant bayous and sluggish streams entering it. The

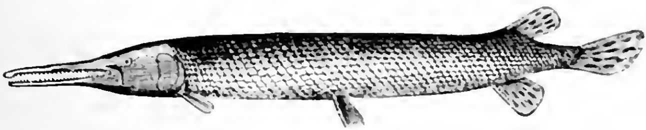


FIG. 197.—Garpike.

spawn resembles that of the toad, forming long ropes several inches in diameter, which are hung on old snags or roots. The eggs are laid in December and January, the young appearing in the spring, becoming fourteen inches long by the end of August.*

* See an interesting account of this remarkable fish, by G. P. Dunbar, in the *American Naturalist* for May, 1882.

The mud-fish of Western and Southern waters (*Amia calva*) is a connecting link between the Ganoids and common or bony fishes. It bears a general resemblance to and is about the size of a bass. Its tail is less "heterocercal" than that of the garpike, and thus it comes nearer to the bony fishes.

SUB-CLASS III.—TELEOSTEI (*Bony Fishes, Perch, Cod, etc.*)

These are our common fishes, of which there are nearly ten thousand species. The bones are small and exceedingly numerous, a number of small bones forming the skull and

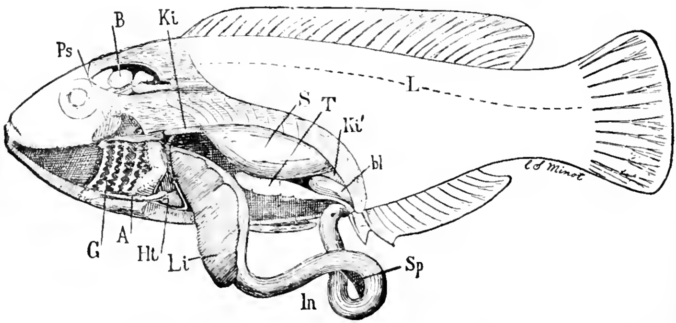


FIG. 198.—Anatomy of the Cunner, male. *L*, lateral line; *Ht*, heart; *Ps*, pseudobranchia; *Sp*, spleen; *S*, air-bladder; *Ki*, *Ki'*, kidney; *bl*, bladder; *T*, testis; *A*, aorta; *B*, brain; *In*, intestine; *Li*, liver; *G*, gills. Drawn by C. S. Minot.

supporting the fins, so that we may in a single fish count upwards of five hundred separate bones. In these fishes there are four gills on each side, the single gill-opening being covered with a lid or operculum composed of four thin bones.

We would advise the student to dissect a perch, smelt, or any fish, with the aid of the following description of the anatomy of the sea-perch, which closely resembles the fresh-water perch. With a pair of forceps, sharp scissors and knife the student, by the exercise of care, may make a very fair dissection.

To dissect a perch the side-wall of the mouth must be removed, then the gill-cover; study the arrangement of the gills. Next make an incision along the median ventral line from the level of the pectoral fins to just before the anus, and following the upper edge of the body-cavity upward and forward cut away the body-wall, taking care not to injure the large swimming bladder above, nor the heart in front. Now open the pericardial cavity, which lies immediately behind and below the gills (see Fig. 198, *Ht*). Cut away the muscular masses around the back of the head; expose the cavity of the brain, and remove the loose cellular tissue around the brain. If the gills of one side are cut away and the intestine drawn out, the dissection will appear very much as in Fig. 198.

The cavity of the mouth widens rapidly, becoming behind the branchial chamber or pharynx, whence we can pass a probe outward

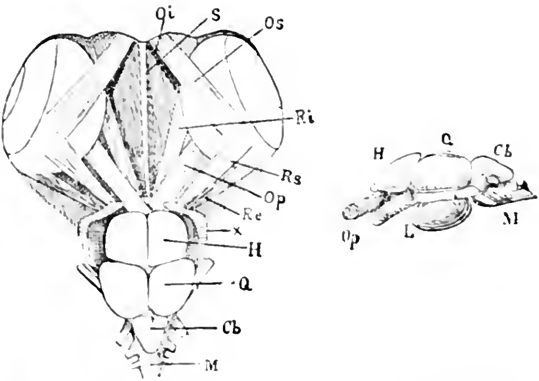


FIG. 199.—Anatomy of the brain of the Cunner, dorsal and side view. *B. Ol.* olfactory lobes; the crura and the thalami not represented; *H*, cerebral hemispheres; *Q*, optic lobes; *Cb*, cerebellum; *M*, medulla.

through any of the gill-slits. There is a single row of sharp pointed teeth in front on both the under and upper jaws; in the pharynx above and below there are rounded teeth. At the side of the pharynx are the four gill-slits and the four arches. The entrance of each slit is guarded in front and behind by a row of projecting tubercles appended to the arches. On the outside of each arch, except the fourth, is a double row of filaments, richly supplied with blood-vessels which, shining through, give a brilliant red color to the gills; on the fourth arch there is but a single row. At the upper and posterior corner of the pharynx is the small opening of the short œsophagus. The branchial chamber has an upward extension on the sides of which lie the false gills (*Ps*), which are accessory respiratory organs not connected with the gills proper, and receiving their blood-supply from distinct arteries.

The œsophagus dilates almost immediately to form the stomach (partly concealed in the figure by the liver, *Li*), which is hardly thicker than the intestine (*In*). This last is of nearly uniform size throughout, and after making three or four coils terminates at the anus, immediately in front of the urinary and genital apertures. The liver (*Li*) forms an elongated light-brown mass resting upon the stomach. The elongated gall-bladder lies between the liver and stomach, somewhat imbedded in the substance of the former. There is no pancreas, though it is present in some fishes. The spleen (*Sp*) lies between the stomach and intestine, in the mesentery; it is dark reddish-brown in color.

The air-bladder (*S*) is a single large glistening sac, placed in the dorsal part of the body-cavity. The air-bladder normally contains only gases. It conceals most of the kidneys, which extend the whole length of the body-cavity on either side of the middle line, as two long strips of a deep though dull red. They project beyond the air-bladder in front (*Ki*) and behind (*Ki'*).

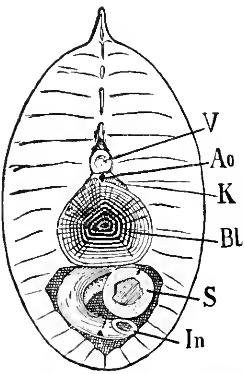


FIG. 200.—Transverse section through the middle of the body of a Cunner. Drawn by C. S. Minot.

The ovary is single, and varies greatly in size according to the season. In the male the sexual glands (testes) are double.

The heart (*Ht*) lies in the triangular pericardial cavity; it consists of two portions, the dark-colored venous chamber, or auricle, above, and the lighter-colored arterial chamber, or ventricle, below. The auricle receives from above two large veins, one from either side; these veins are called the Cuvierian ducts. Furthermore, a large vein, the sole representative of the *vena cava* of higher vertebrates, passes from the liver, near its anterior end, through the pericardium, and empties into the Cuvierian ducts near their common auricular orifice.

The brain should be exposed from above by carefully removing by a knife the skin and thin bones covering the brain-cavity. Beginning in front, we notice the minute olfactory lobes and the olfactory nerves proceeding to the nasal cavities. Behind the olfactory lobes lie in succession the *cerebral hemispheres* (*H*), *optic lobes* (*Q*), the single *cerebellum* (*Cb*), and, lastly, the *medulla oblongata* (*M*).

A general idea of the two body-cavities, the nervous and visceral, will be obtained by cutting the fish through transversely. The nervous cord is seen to lie above the vertebral column, the nervous canal being formed by the interarching spinous process. Below the vertebral column is the large cavity containing the heart, stomach, etc., while the rest of the section is occupied by muscles. (C. S. Minot.)

The noises produced by certain fishes are due to the action of the pneumatic duct and swimming-bladder (Fig. 201, *S*, *S'*), though different kinds of noises are made accidentally or involuntarily by the lips or the bones of the mouth, as in the tench, carp, and a large number of other fishes. Over fifty species of fish are known to produce sounds of some sort. The swimming-bladders of *Trigla* and

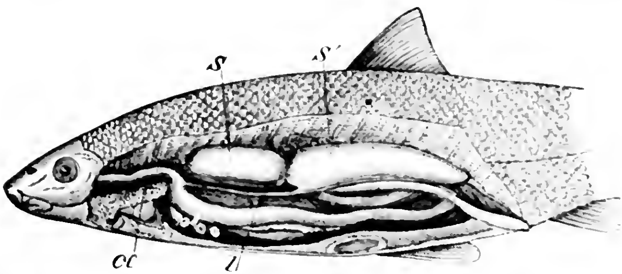


Fig. 201.—Swimming bladder (*S*, anterior, *S'*, posterior division) of the bleak; *oe*, oesophagus; *l*, air-passage of the air-bladder leading into the oesophagus. From Semper.

Zeus have a diaphragm and muscles for opening and closing it, by which a murmuring sound is made. The loudest sounds are made by the drum-fish. In some minnows, pouts, and eels the sound is made by forcing the air from the swimming-bladder into the oesophagus. In the sea-horse, the sounds are caused by the vibrations of certain small voluntary muscles.

The mud sun-fish (*Acantharchus pomotis*) utters a deep grunting sound; the gizzard shad (*Dorosoma cepedianum*, Fig. 202) makes "an audible whirring sound;" the chub-sucker or mullet (*Erimyzon oblongum*) "utters a single prolonged note accompanied by a discharge of air-bubbles;" the cat-fish produces "a gentle humming sound;" eels utter a more distinctly musical sound than any other of those observed by Abbot, who states that "it is a single note, frequently repeated, and has a slightly metallic resonance." It should also be noticed that the organs of hearing in many musical fishes are said to be unusually well developed, hence these sounds are probably love-notes; and Abbot notices the fact that these fishes are dull-colored during the reproductive season, as well as at other times, while voiceless fishes, such as the perch, common sun fish, chub, roach, etc., are highly colored during the breeding

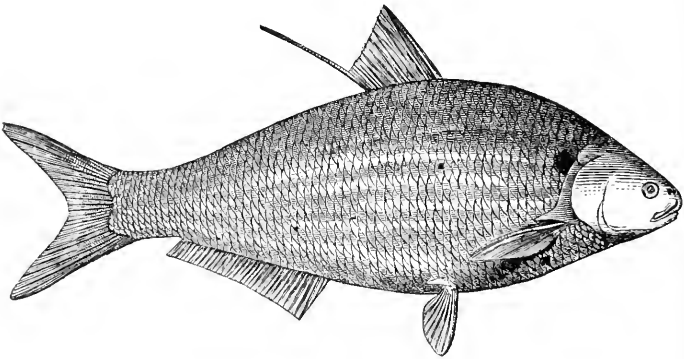


FIG. 202.—Gizzard Shad.

season, and thus the sexes are mutually attracted in the one case by music, and in the other by bright colors. Finally, the sounds of fishes may be compared with those of reptiles, birds and mammals, the air-bladder corresponding to the lungs of the higher Vertebrates, while the pneumatic duct is comparable with the trachea of birds and mammals.

In swimming, the propelling motion is mainly exerted by the tail, the movements of which are somewhat like those of an oar in sculling. The spines of the tail-fin are movable, and are capable of being brought into such a position that the fin will meet with less resistance from the water while the tail is bent; they are then straightened, and it is when being straightened that the fish is propelled. The movements of the pectorals and ventrals are to steady the fish and to elevate and depress it, while the dorsal and anal fins steady the body and keep it upright, like a dorsal and ventral keel.

Among viviparous bony fishes are certain Cyprinodonts (as *Anableps* and *Pœcilia*), the eel-like *Zoarces*, and the blind-fish of the Mammoth Cave. A small family of Californian marine fishes, resembling the sun-fish (Pomotis), are called by Agassiz *Embiotocidæ*, from the fact that they bring forth their young alive. *Embiotoca Jacksoni* Agassiz, which is twenty-seven and a half centimetres ($10\frac{1}{2}$ inches) long, has been known to produce nineteen young, each about seven and a half centimetres (3 inches) long.

During their breeding season, many bony fishes, such as the stickleback, salmon, and pike, are more highly colored than at other times, the males being especially brilliant in their hues.

Orders of Bony Fishes.

Order 1. Body long; ventral fins either abdominal or wanting... *Opisthomi* (Notacanthus).

Order 2. Body long, snake-like, no ventral fins.................. *Apodes* (Anguilla, Eel).

Order 3. Body broad; lips with barbels........................ *Nematognathi* (Amiurus, Pouts).

Order 4. Body more or less oblong (in African rivers)........ *Scyphophori* (Mormyrus).

Order 5. Body usually compressed; all the bones and fins well developed............... *Teleocephali* (Salmo, Perca, Gadus).

Order 6. Head and mouth very large; pectoral fins supported by slender bones.............. *Pediculati* (Lophius, Goose-fish).

Order 7. Gills tufted; body long and slender.................. *Lophobranchii* (Hippocampus).

Order 8. Bones of upper and lower jaw united; often rounded and spiny...................... *Plectognathi* (Tetrodon, Mola).

Order 1. *Opisthomi.*—In these fishes the ventral fins are either abdominal or wanting. The typical genus is *Notocanthus*, in which the body is elongated, with a proboscis-like snout.

Order 2. *Apodes* (Eel).—The branchial apertures are unusually small, and there are no ventral fins, while the body is very long, cylindrical, snake-like. The conger-eel (*Conger oceanicus*) ranges from Newfoundland to the West Indies.

The common eel, *Anguilla acutirostris* (Fig. 203), occurs on both sides of the Atlantic, on the North American coast as far south as Cape Hatteras, and in inland rivers and

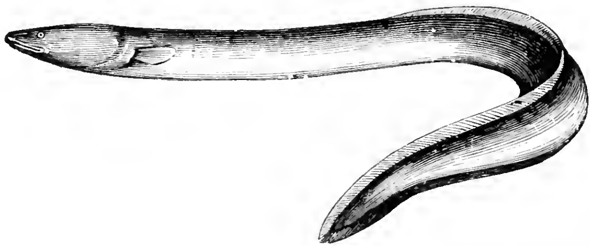


FIG. 203.—Common Eel, *Anguilla acutirostris.*

lakes. The males are extremely rare, only four having been found in this country. It is probable that the eel descends rivers in October and November, spawning in the autumn and early winter at the mouth of rivers, and in harbors and estuaries in shallow water. By the end of the spring the young eels are two or three inches long, and then ascend rivers and streams. They grow about an inch a month, and the females do not spawn at least before the second year, *i.e.*, when about twenty inches long. Mr. Mather estimates that the ovary of an eel weighing six pounds when in spawn contains upwards of 9,000,000 eggs.

Order 3. *Nematognathi* (Catfish, Pouts, etc.).—The name of the order (from *νῆμα, νήματος*, thread, and *γναθος*, jaw) is in allusion to the filaments or barbels growing out from the jaws, and which are characteristic of the members of the group.

The horned pout (*Amiurus atrarius*) lays its eggs in holes in gravel during midsummer. The Great Lake catfish is sometimes a metre in length.

In certain Siluroid fish in tropical seas, as *Arius* (Fig. 204), the eggs are carried by the males in their mouth, from five to twenty being thus borne about until the young hatch. They are probably caught up after exclusion and fertilization. Some of these eggs are half an inch in diameter.

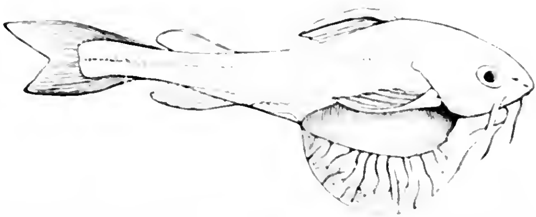


FIG. 204.—Young Arius with its yolk-sac, probably taken from the mouth of its male parent.

In Aspredo (Fig. 205) the eggs are attached to the outside of the body by slender stalks.

Order 5. *Teleocephali* (cod, perch, trout, etc.).—This group comprises most of the bony fishes; and they are the most specially developed of all fishes.

Beginning with the lower kinds, we have the electrical eel (*Gymnotus electricus* Linn.) of South America, which is two metres in length, and is characterized by its greatly developed electrical batteries. These are four in number, situated two on each side of the body, and together form nearly the whole lower half of the trunk. The plates of the cells are vertical instead of horizontal, as in the torpedo, while the entire batteries or cells are horizontal, instead of vertical, as in the electrical ray. The nerves sent to the batteries of the eel are supplied by the ventral branches of about two hundred pairs of spinal nerves.

Succeeding these fish are the herrings, represented by the common English herring, *Clupea harengus,* which inhabits both sides of the North Atlantic, extending on the American side from the polar regions to Cape Cod; the alewife, *Pomolobus pseudoharengus,* which ranges from Newfoundland to Florida; the shad, *Alosa sapidissima,* which has the same geographical distribution as the alewife; and the menhaden or pogy, *Brevoortia tyrannus,* which extends from the coast of Maine to Cape Hatteras. These, with the cod, hake, haddock, salmon, and a few other species, comprise our most valuable marine food-fishes. The fisheries of the United States yield about $44,000,000 annually, whilst those of Great Britain amount in value to about $40,000,000, and those of Norway to about $10,000,000.

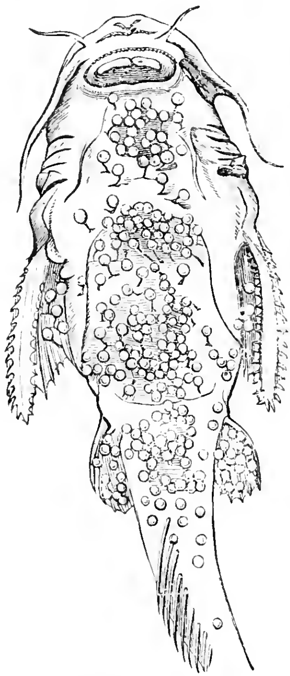


FIG. 205.—*Aspredo*, a Siluroid fish, with little sacs filled with eggs attached by slender stalks.

The herring (Fig. 206) is a deep-water fish which visits the coast in spring in immense schools, in which the females are three times as numerous as the males, to spawn, selecting shoal water from three to four fathoms deep in bays, where the eggs hatch. At this season, and early in the summer, hundreds of millions are caught, especially on the Canadian, Newfoundland, and Labrador coasts. The English whitebait is the young of the herring. The herring is caught in deep nets with meshes large enough to capture individuals of ordinary size, the nets having a finer mesh than those used for the mackerel fishery.

The alewife and shad are said to be *anadromous*, from their habit early in spring of visiting the coast and ascending rivers in vast numbers to spawn. The eggs are of moderate size; the ovaries are said to contain about 25,000, and at times as many as 100,000 or 150,000 eggs. They are discharged near the surface, sinking slowly to the bottom. The shad eats little or nothing in fresh water, being then engaged in spawning. In the sea they live on small shrimps. The menhaden is now put up as a substitute for sardines,

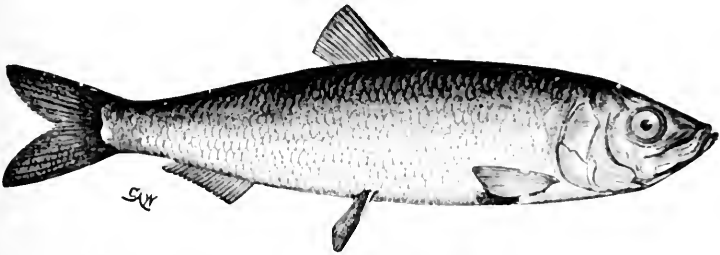


FIG. 206.—The Herring, *Clupea harengus*, one third natural size.

and is of great value as fish-bait, especially in the mackerel fishery, and for its oil.

The family *Salmonidæ* comprises the salmon, trout, and whitefish, with a number of species and varieties. The species of the genus *Salmo* have not more than eleven rays to the anal fin, while the salmon of the west coast, *quinnat*, has fifteen or sixteen anal rays. The eastern salmon (*Salmo salar*) sometimes weighs eighty pounds. It is common to Europe as well as Northeastern America. In the autumn the salmon ascends rivers to spawn, penetrating as near the source as possible. During the breeding season the males differ decidedly from the females, in the long, slender, hooked snout, the body being thin and high colored. The eggs are very large, exceeding a pea in size, and are laid in shallow holes made in the gravel of streams. The extreme young is banded and called *parr;* when about a year old, and of a bright silvery color, before descending the rivers to the sea, it is called a *smolt;* after its return from the sea into fresh water it goes by the name of *grilse;* and finally, after returning a second time from the sea, it assumes its name of salmon. The trout (*Salmo fontinalis*) also breeds in the autumn and early winter; it is not migratory, living permanently in streams and ponds.

An allied family embraces the smelt (Fig. 207). The capelin (*Mullotus villosus*) is valuable as bait in the cod fishery. It spawns in the summer. The males are distinguished by a prominent lateral ridge along the sides of the body, and are more numerous than the females.

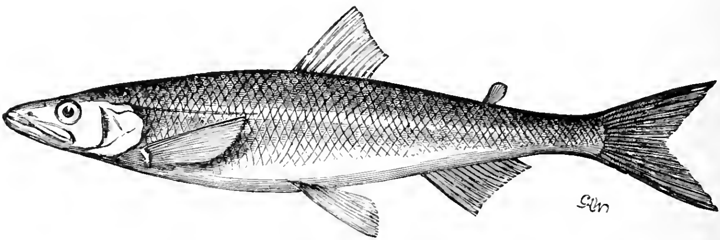


Fig. 207.—The Smelt, *Osmerus mordax*; one half natural size.

The carps (*Cyprinus*), shiners, and minnows abound everywhere in the Northern States in ponds and weedy streams. The breeding habits of the dace (*Rhinichthys atronasus*) are interesting. The females spawn over "nests" or shallow depressions two feet in diameter in running brooks about a foot deep; the male passes over the eggs fertilizing them; then the pair bring small pebbles which are dropped over the eggs, until layer after layer alternately of eggs and pebbles are deposited, when a heap is formed, the young hatching out and remaining among the pebbles until old enough to venture out into the stream. The dace is closely allied to the chub (*Semotilus rhotheus*, Fig. 209).

Succeeding them are the suckers (family *Catostomidæ*) of which *Catostomus teres* is an example.

The blind fish of the Mammoth and other caves, and of adjoining wells connecting with subterranean streams, are remarkable for the rudimentary state of the eyes, and consequent loss of color. There are but two species, the more common and larger being *Amblyopsis spelæus;* this species is viviparous. Representing the family *Umbridæ* is the mud-minnow (*Melanura limi*, Fig. 208).

The flying-fish represent another family. Their pectoral fins are very broad and large. They dart from the water with great speed without reference to the course of the wind and waves. They are said to make slight flying motions

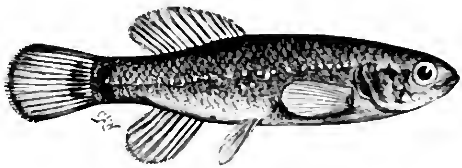


FIG. 208.—Mud-Minnow.

with their pectoral and ventral fins, very rapid vibrations being seen in the outstretched pectoral fins. They usually fly farther against the wind than with it, or if their track and the direction of the wind form an angle. Most flying-fish which fly against or with the wind continue in their whole course of flight in the same direction in which they come out of the water. If in strong winds they fly against the course of the waves, then they fly a little higher; sometimes they cut with the tail into the crest of the waves. Only such flying-fish rise to a considerable height (at the highest, by chance, five metres above the surface of the sea) whose course in the air becomes obstructed by a vessel. In the daytime flying-fish seldom fall on the deck of the ship, but mostly in the night; never in a calm, but only when the wind blows.

Following the flying-fish is the family represented by the silver gar or bill-fish (*Belone longirostrus* Mitchill, Fig. 210).

The sucker (*Echeneis remora* Linn.) occurs along the whole coast of the United States, and is found all over the

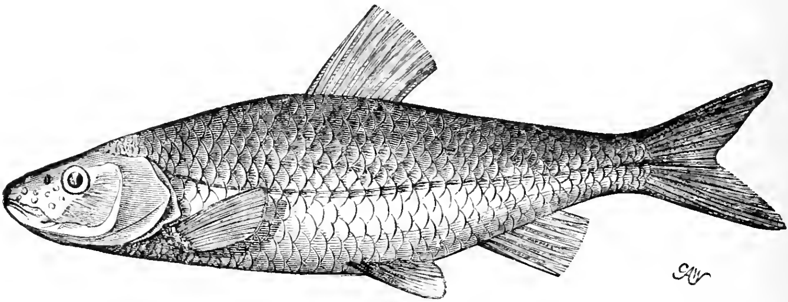


FIG. 209.—The Large Chub, *Semotilus rhotheus*, one fifth natural size. From Abbot.

tropical and subtropical seas. It is provided with a broad oval sucker on the upper side of the head, by which it adheres to other fish or even to ships, and may thus be transported long distances. Another noticeable member of the

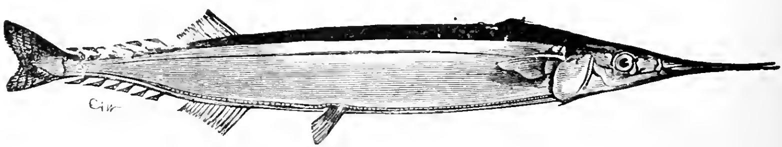


FIG. 210.—The Bill-fish, *Belone longirostrus*, one third natural size.

order is the blue-fish (*Pomatomus saltatrix*, Fig. 211), so valuable as a food-fish.

The dolphin (*Coryphæna*) is sometimes found upon our coast, but it is essentially a pelagic fish, *i.e.*, occurring only out of sight of land upon the high seas. The pilot-fish is also a pelagic form.

The percoid fishes are represented by the perch (*Perca fluviatilis*), which spawns in winter, making slight hollows in the gravel in shoal places in ponds; their movements can be watched through the ice. On the other hand, the sun-fish or bream (*Eupomotis aureus*) spawns in the summer time, making a nest, which it scoops out of the river bot-

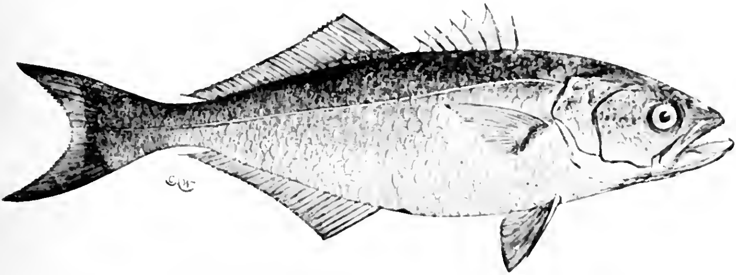


Fig. 211.—The Blue-fish, *Pomatomus saltatrix*, one sixth natural size.

tom. The banded sun-fish (*Mesogonistius chætodon*) occasionally scoops out a little basin in the sand, in which it deposits its eggs late in the spring. The spotted sun-fish (*Enneacanthus obesus*, Fig. 212) lives in muddy streams,

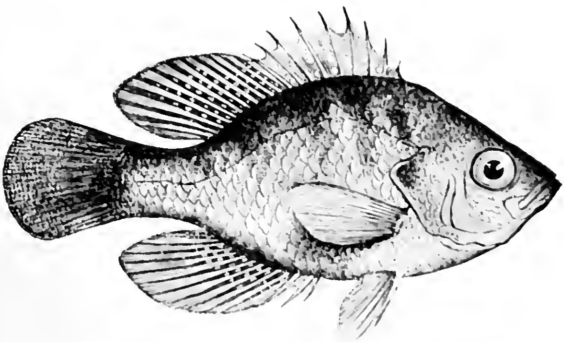


Fig. 212.—The Spotted Sun-fish, *Enneacanthus obesus*.

burying itself in the mud in winter. Of similar mud-loving habits is the mud-minnow (*Melanura limi* Agassiz), which spawns in the spring. The pirate perch (*Aphredo-*

derus sayanus De Kay) occupies the nest of the common sun-fish, and with the female guards it and afterwards he young till they are nearly a centimetre (two-fifths inch) in length, when they are left by their parents. (Abbot.)

The darters, *Etheostomidæ*, belong near the perches, and comprise the smallest of fishes. They inhabit the streams

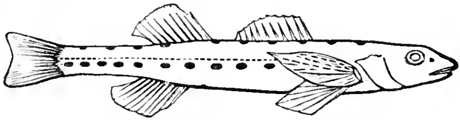


FIG. 213.—Sand-Darter. After Jordan.

of the Mississippi Valley. A common example is the sand-darter (*Pleurolepis pellucidus*, Fig. 213).

The male stickleback (*Gasterosteus*) makes an elaborate nest of leaves, etc., suspended in mid-water, within which it remains watching the eggs and young.

One of the most valuable food-fishes is the mackerel (*Scomber scombrus*, Fig. 214), whose range is from Green

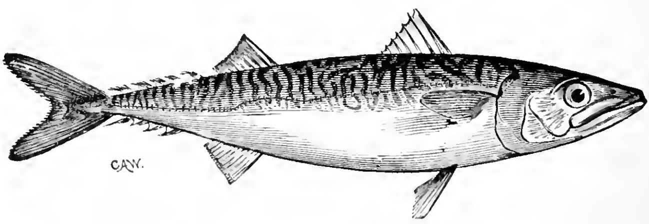


FIG. 214.—The Mackerel, *Scomber scombrus*, one quarter natural size.

land to Cape Hatteras. It remains in deep water during the late autumn and winter, approaching the coast in May and June for the purpose of spawning, its annual appearance being very regular. The number of eggs deposited in one season by each female is said to be from five to six hundred thousand. After spawning they move northward, following the coast until they are checked by the coolness of the water, when they return, and in November seek the deep water again. When spawning they do not take the hook; they are then lean; but at the time of their departure from the coast they are fat and plump. The eggs of the mackerel as well as of the cod are so light as to rise to the surface, where they develop. Allied to the mackerel, though of great size, are the horse-mackerel and the sword-fish, whose upper jaw is greatly prolonged.

The singular *Anabas* of the East Indies is the representative of a small group of fishes called *Labyrinthici* or labyrinth-fishes, in allusion to a cavity on the upper side of the branchial cavity on the first gill-arches, containing a labyrinthine organ, which consists of thin plates, developed from the upper pharyngeal bones, enabling the fish to live for a long time out of water. *Anabas scandens*, of the fresh waters of India, will travel over dry land from one pond to another, and is even said to climb trees by means of the spines in its fins.

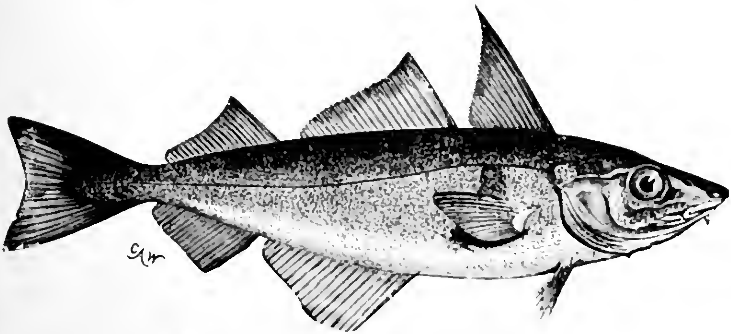


FIG. 215.—The Haddock, *Melanogrammus æglefinus.*

Near the head of the order stands the cunner (*Tautogolabrus adspersus*), whose anatomy is represented by Figs. 198–200. Passing over the tautog, the voracious wolf-fish (*Anarrhichas*), the blennies (*Blenniidæ*), in which the body is long and narrow, and the viviparous eel-pout (*Zoarces*), the cottoids or sculpins, and a number of allied forms, we come to the hake (*Merlucius bilinearis*), the haddock (*Melanogrammus æglefinus*, Fig. 215), and cod (*Gadus morrhua* Fig. 216), all of which extend northwards from Cape Hatteras, the cod abounding on both sides of the Atlantic, being a circumpolar fish. The cod does not, as formerly supposed, migrate along the coast, but seeks the cool tem perature to which it is adapted by gradually passing in the early summer from shallow to deep water, and returning as the season grows colder. It visits the shallow water of Massachusetts Bay to spawn about the first of November, and towards the last of the month deposits its eggs. About eight or nine million of eggs are annually deposited by each

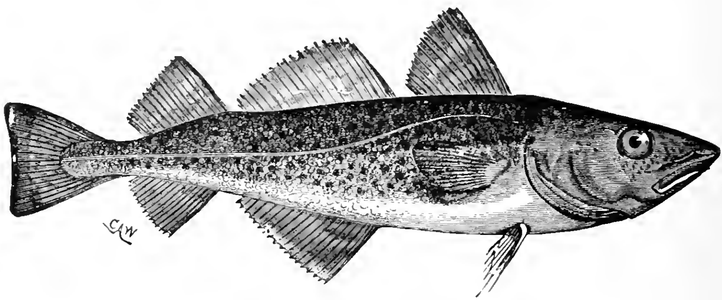


FIG. 216.—The Cod-fish, *Gadus morrhua.*

female. The eggs laid by the cod rise to the surface of the water, on which they float. The young fish hatch on the New England coast in twenty days after they are extruded.

The cod is the most important of all the food-fishes, whether we consider the number taken or the amount of capital involved in the cod-fishery. It abounds most on the Grand Banks of Newfoundland. The breeding habits of the haddock, hake, and pollock are probably like those of the cod.

Fierasfer is a small eel-like fish, with a long, thin tail. It is typical of a peculiar family, and is noteworthy from being a "commensal" or boarder in the digestive canal of

Holothurians, etc. *F. acus* lives in Holothurians, and another species in a star-fish.

At the head of the *Teleocephali* stand the flounders, halibut, and soles, which are an extremely modified type of the order. In these fishes the body is very unsymmetrical, the fish virtually swimming on one side, the eyes being on the upper side of the head. The upper side is colored dark, due as in other fishes to pigment-cells; the lower side is colorless, the pigment-cells being undeveloped. When first hatched the body of the flounder is symmetrical, and in form is somewhat cylindrical, like the young of other fishes,

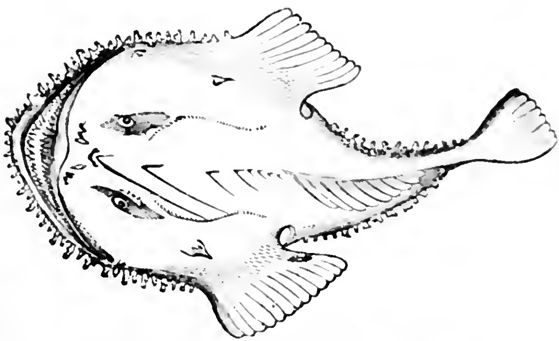


FIG. 217.—Goose-fish, one tenth natural size.

swimming vertically as they do, and with pigment-cells on the under side of the body. The flounder is not born with the eyes on the same side of the head, but one eye gradually passes from the blind to the colored side; the transfer of the eye from the blind side to the colored side occurs very early in life, while all the facial bones of the skull are still cartilaginous, long before they become hard and ossified, *i.e.*, when the flounder (*Plagusia*) is twenty-five millimetres (one inch) long. Young flounders, when less than two inches in length, are remarkably active compared with the adults, darting rapidly through the water after their food, which consists principally of larval surface-swimming crustaceans, etc. The common flounder from Nova Scotia to Cape Hatteras is *Pseudopleuronectes Americanus.*

Order 6. *Pediculati.*—The type of this order is the goose-fish. The name was given to the group from the long

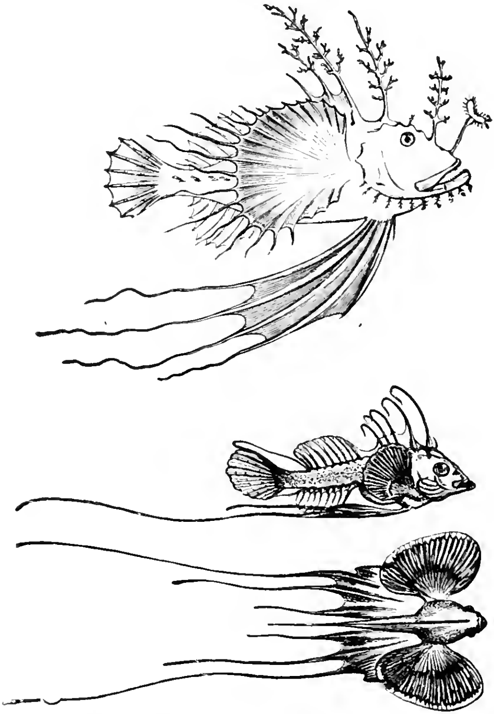


FIG. 218.—Young Anglers at different ages. After Lütken.

slender bones supporting the pectoral fins. The gill-openings are small and placed in the axils of the pectoral fins. *Lophius piscatorius,* the goose-fish or angler (Fig. 217) has an enormous mouth, and swallows fishes nearly as large as itself. Its eggs are laid in broad, ribbon-like, thin, gelatinous masses, two metres long and half a metre wide, which float on the surface of the ocean. To this order belongs also the toad-fish (Fig. 219).

Order 7. Lophobranchii.—The tufted-gilled fish—such

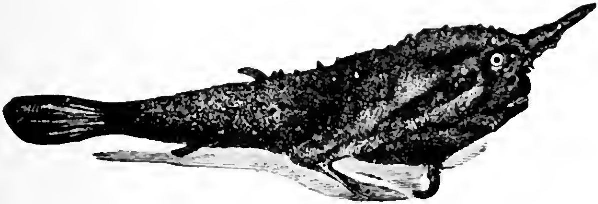


FIG. 219.—Toad fish. After Lütken.

being the meaning of the name of the order—comprise the pipe-fish and sea-horse.

The male of the pipe-fish (*Syngnathus peckianus*) receives from the female the eggs, and carries them in a

FIG. 220.—Sea-horse, male, with the young issuing from the brood pouch.

small pouch under his tail, which is grooved beneath. The sea-horse (*Hippocampus hudsonius*, Fig. 220) lives off-shore from Cape Cod to Cape Hatteras. The male has a pouch situated on the breast. By simple mechanical pressure of its tail, or by rubbing against some fixed object, as a shell, it forces the fry, to the number of about a thousand, out of its brood-pouch, the young at this time measuring about twelve millimetres (5–6 lines) in length.

Order 8. *Plectognathi.*—This group, represented by a

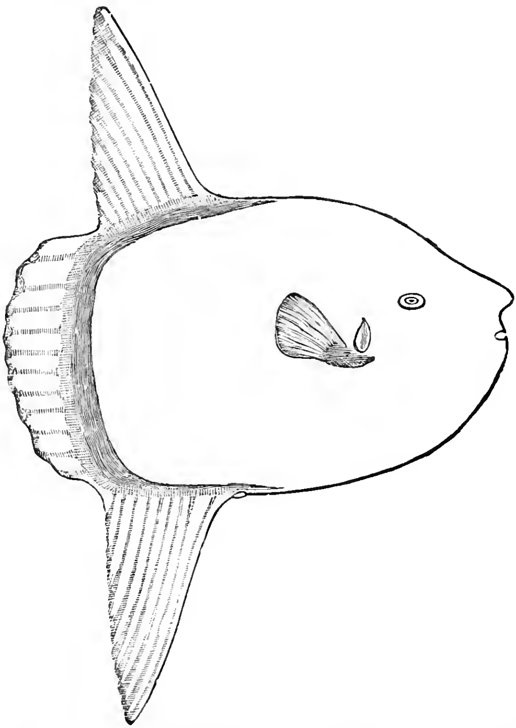


FIG. 221.—Sun-fish, *Mola rotunda*, one eighteenth natural size.

few singular forms, such as the trunk-fish, file-fish, puffers, and sun-fish, is characterized by the union of the bones of the upper and especially the lower jaws. The ventral fins are usually absent, and the skin is often spiny. They are inhabitants of warm waters. The trunk-fish or box-fish, *Lactophrys trigonus*, is a West Indian fish; one specimen has appeared at Holmes' Hole, Mass. The porcupine-fish (*Chilichthys turgidus*) and smooth puffer (*Tetrodon laevigatus*) and the spring box-fish (*Chilomycterus geometricus*) range from Cape Cod to Florida. The sun-fish (*Mola rotunda*, Fig. 221) is, like the others of the order, a surface-swimmer. It is sometimes a metre or more in length, weighing five hundred pounds or more.

A very strange fish of unknown affinities is the *Eurypharynx* (Fig. 222), which was dredged in the Mediterranean Sea at a depth of 2300 metres (1200 fathoms). It is

Fig. 222.—*Eurypharynx pelecanoides*. From Lütken.

.47 metres (18 inches) long, with an enormous mouth; it is without fins, and it differs from all other bony fishes in having six pairs of internal branchial slits and consequently five pairs of gills.

Class V.—Batrachia (*Salamanders, Toads, and Frogs*).

General Characters of Batrachians.—We now come to air-breathing vertebrates, with legs and lungs, and with ribs. The Amphibians, with the exception of the toads and frogs, are often mistaken for lizards, but the skin is always smooth, not sealed as in true reptiles, and the toes are not provided with claws. These animals are called Amphibians because they live a part of their lives in the water. All Amphibians, with very rare exceptions, pass through a metamorphosis; the young or larvæ are called tadpoles; their form is fish-like, as they breathe by external gills, and do not at first have legs.

An examination of the skeleton shows that the skull resembles that of the higher vertebrates in being composed of few pieces, while there are short ribs, and a true shoulder and pelvic girdle to which the limb-bones are joined. The

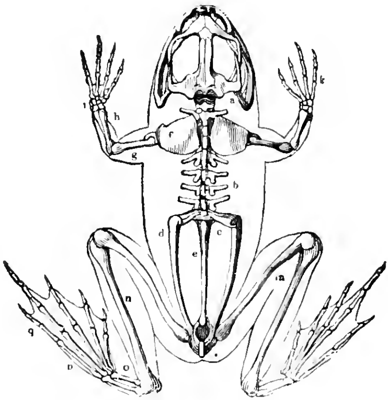


FIG. 223.—Skeleton of a Frog. *a*, skull; *b*, vertebræ; *c*, sacrum, and *e*, its continuation (urostyle); *f*, suprascapula; *g*, humerus; *h*, fore-arm bones; *i*, wrist-bones (carpals and metacarpals); *d*, ilium; *m*, thigh (femur); *n*, leg-bone (ulna); *o*, elongated first pair of ankle-bones (tarsals); *p*, *q*, foot-bones or phalanges. After Owen.

heart is 3-chambered, there being two auricles and one ventricle.

Like fishes, Batrachians are highly colored in the spring during the breeding season. The males of the newts at this time acquire the dorsal crest and a broader tail-fin, while in some species prehensile claws are temporarily developed on the fore-legs of the male. Male toads and frogs are musical, the females being comparatively silent; the vocal organs of the male are more developed than in the females, and in the European edible frog large sacs for producing a greater volume of sound swell out on each side of the head of the males. Among the few viviparous Batrachians known is an Alpine European salamander (*S. atra*) which brings forth its young alive.

Unlike young fishes, the yolk is entirely absorbed before

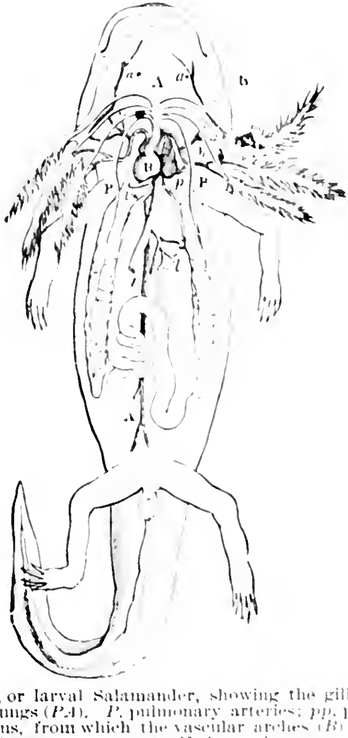


FIG. 221.—*Axolotl*, or larval Salamander, showing the gills, heart (*H*), aortic branches and lungs (*PA*). *P*, pulmonary arteries; *pp*, pulmonary veins. *A*, bulbus arteriosus, from which the vascular arches (*B*) originate; *bb*, branchial vein; the lower *A*, vena cava; *V*, descending aorta.

the tadpole leaves the egg. In warm climates the tadpoles hatch in four or five days after the eggs are laid. When hatched the tadpole is not so well developed as in most young fishes. The digestive canal at first is simple and straight. Afterwards it becomes remarkably long, and coiled in a close spiral. The mouth is small (Fig. 225, *A*), with no tongue and only horny toothless jaws. The vertebræ of the tadpole are biconcave as in fishes, afterwards becoming converted into cup-and-ball joints.

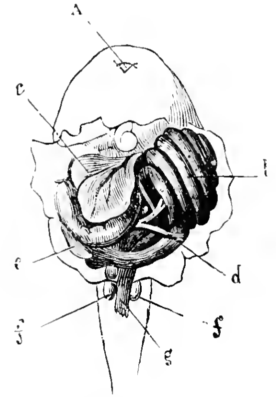


FIG. 225.—Mouth and digestive canal of a Tadpole. *A*, mouth; *b*, intestine coiled on itself; *c*, liver; *d*, hepatic duct; *e*, pancreas; *f*, rudimentary hind legs; *g*, rectum.

The accompanying figures represent the external changes of the toad from the time it is hatched until the form of the adult is attained. The tadpoles of our American toad are smaller and blacker in all stages of growth than those of the frog. The tadpole is at first without any limbs (Fig. 226, *A*), and with two pairs of gills; soon the hinder pair bud out. After this stage (*B*) is reached, the body begins to diminish in size. Then the fore-legs grow out (*C*); and finally, as at *D*, the tail is mostly absorbed, and at *E* we see the little toad which hops about on the bank.

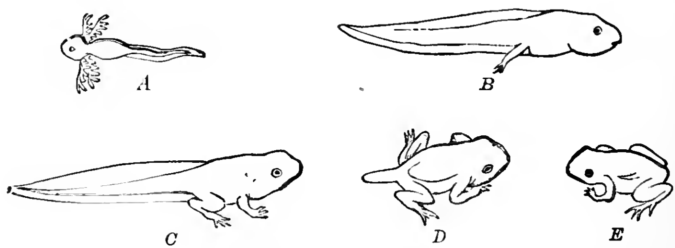


FIG. 226.—Different stages of the Toad.

There are nearly 700 species of this class now living, of which 101 are North American.

The Batrachians are an old-fashioned type: certain fossil, extinct tailed forms were as large as whales, being over thirty feet in length.

ORDERS OF BATRACHIA.

1. Body long, eel-like, with gills, no hind legs .... *Trachystomata* (Siren).
2. Body flat, with gills, four legs .... *Proteida* (Mud-puppy).
3. No gills in adult life .... *Urodela* (Salamanders).
4. Body snake like; no feet, no tail ..... *Gymnophiona* (Blind Snake).
5. Tailless, with four legs, long toes; great leapers; young tailed .... *Anura* (Toads, Frogs).

Order 1. *Trachystomata* (Sirens).—These singular creatures are eel-like in their form and movements, with gills on the sides of the head. They have no hind legs, and the small weak fore-legs are three- or four-toed. The great siren, *Siren lacertina*, is two or three feet in length, and is four-toed. It lives in swamps and bayous in the Southern States, especially rice lands. It lives in the mud, going on land or swimming in the water. Its food is supposed to be earth-worms, insects, etc. A smaller siren, 9 inches in length with three toes and small gills, is the *Pseudobranchus striatus*. It is found in Georgia.

Order 2. *Proteida* (Proteus; Necturus, mud-puppy).—These Amphibians are flat-bodied, with bushy thick gills, of a beautiful deep red beneath, with gill-openings, while the jaws are armed with small conical teeth.

The *Proteus* of Austrian caves is blind; it has three toes in the fore-feet and two in the hinder pair. Our American Protean is four-toed on all the feet. The mud-puppy or Menobranchus (*Necturus lateralis*) is a large, broad, flat-bodied, fish-like creature. It is brown, mottled with darker spots; it has small eyes, and is from 8 inches to 2 feet in length. It inhabits the Mississippi Valley, and is common in the lakes of Central New York, where it is caught with the hook and line. It is easily kept in confinement, eating bits of meat.

Order 3. *Urodela* (Salamanders, Newts).—These tailed Amphibians rarely have gills when mature, these organs in them being larval or transitory. The body is still long and fish-like, the tail sometimes with a caudal fin as in the newts, but usually rounded, while the four legs are always present. One or two of the salamanders living away from water bring forth their young alive; but as a rule salamanders lay their eggs in the water. The eggs of the newt (Triton) are laid singly on submerged leaves; those of the spotted newt are also laid singly on the leaves of floating plants. Those of *Desmognathus* are laid connected by a tough thread on land. The common red-backed salamander, or *Plethodon erythronotum*, lays its eggs in summer in packets under damp stones, leaves, etc.; the young are born with gills, as is the case with the viviparous *Salamandra atra* of the Alps. This species is said by John Burroughs * to make a "fine plaintive piping noise, heard from May till November through all our woods, sometimes on trees, but usually on or near the ground."

The lowest form of this order is the aquatic Congo-snake (*Amphiuma means*), in which the body is large, very long, round and slender, with small rudimentary two-toed limbs; there are no gills, though spiracles or gill-openings survive. It lives in swamps and sluggish streams of the Southern States.

A step higher is the *Menopoma*, which is still aquatic, but without gills, while the body and feet are as in the true salamanders. The *Menopoma Alleghaniense* (Fig. 227), called the hellbender or big water lizard, is about half a metre ($1\frac{1}{2}$–2 feet) in length, and inhabits the Mississippi Valley. Allied to the Amphiuma is the gigantic Japanese salamander, *Cryptobranchus Japonicus*, which is a metre in length.

We now come to the true salamanders, whose body is still tailed, with larger eyes; there are no spiracles; they breathe exclusively by their lungs, except what respiration is carried on by the skin.

The genus *Amblystoma* comprises our largest salamanders;

* "Pepacton." Boston, 1881, p. 133.

they are terrestrial when adult, living in damp places and feeding on insects. The larvæ retain their gills to a period when they are as large or even larger than the parent. The most interesting of all the salamanders is the *Amblystoma mavortium*, whose larva is called the axolotl (Fig. 228).

FIG. 227.—Skeleton of the hell-bender (*Menopoma*). From Lütken's Zoölogy.

This larva is larger than the adult, which lives on land, sometimes being about a third of a metre (12 inches) in length, the adult being twenty centimetres (8 inches) long.

The axolotl or siredon abounds in the lakes of the Rocky Mountain plateau from Montana to Mexico, from an altitude of 4000 to 8000 or 9000 feet; the Mexican axolotl being of a different species, though closely allied to that of Colorado, Utah, and Wyoming. The Mexicans used the animal as food. Late in the summer the siredons at Como Lake, Wyoming, where we have observed them, transform in large numbers into the adult stage, leaving the water and hiding under sticks, etc., on land. Still larger numbers remain in the lake, and breed there. Thousands of the fully-grown siredons are washed ashore in the spring when the ice melts. They do not appear at the surface of the lake until the last of June, and disappear out of sight early in September. The eggs are laid in masses, and are two millimetres in diameter.

The change from the larva to the adult consists, as we

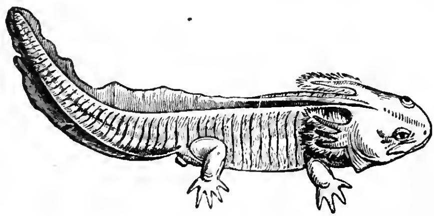


FIG. 228.— Siredon or larval Salamander. From Tenney's Zoology.

have observed, in the absorption of the gills, which disappear in about four days; meanwhile the tail-fins begin to be absorbed, the costal grooves become marked, the head grows smaller, the eyes larger, more protuberant, and the third day after the gills begin to be absorbed the creature becomes dark, spotted, and very active and restless, leaving the water. Their metamorphosis may be greatly retarded and possibly wholly checked by keeping them in deep water.

Experiments made in Europe show that the legs and tail of the axolotl, as of other larval salamanders, may be reproduced. On cutting off a leg of an axolotl the first of November, it was fully reproduced, though of smaller size than the others, a month later. The tail, if partly removed, will grow out again as perfect as ever, vertebræ and all. The larva lays eggs as well as the adult salamander.

The Tritons or water-newts, represented by our common, pretty spotted newt, *Diemyctylus viridescens*, are also

Fig. 229.—Head and tail end of blind-snake (*Cœcilia*). From Lütken's Zoology.

known in Europe to lay eggs when larvæ, when the gills are still present, as has been observed by three different naturalists. The female larva of another European salamander (*Lissotriton punctatus*) has also been known to lay eggs.

Order 4. Gymnophiona.—The blind snake with its several allies is the representative of this small but interesting order. The body is snake-like, being long and cylindrical; there are no feet and no tail, the vent being situated at the blunt end of the body. The skin is smooth externally, with scales embedded in it, but with scale-like transverse wrinkles. The eyes are minute, covered by the skin (Fig. 229). The species inhabit the tropics of South America, Java, Ceylon, and live like earthworms in holes in the damp earth, feeding on insect larvæ. They are large, growing several feet in length. *Cœcilia lumbricoides* inhabits South America. *Cœcilia compressicauda* of Surinam is viviparous, the young being born in water and possessing external gills which are leaf-shaped

Fig. 230.—Young of *Cœcilia*, with the gills, and head of the same after the gills have been absorbed. From Lütken's Zoology.

sacs resting against the sides of the body; when the animal leaves the water they are absorbed, leaving a scar (Fig. 230). *Siphonops Mexicana* is a Mexican form.

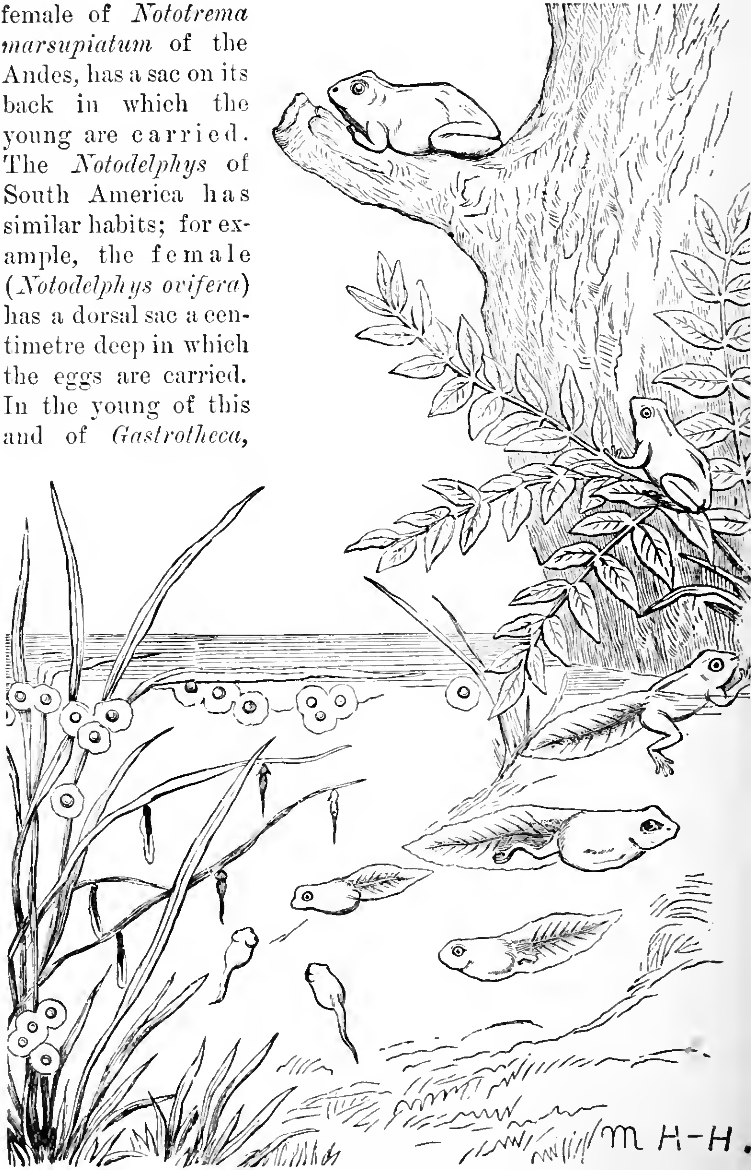
Order 5. *Anura* (Toads and Frogs).—These are the tailless Batrachians. Frogs either live in or by the edge of pools and brooks, and when attacked on land they can by vigorous leaps escape to a place of safety. Unlike other Amphibians, they are powerful leapers, the legs being muscular, and their toes very long. The lower jaw is usually toothless. The larvæ are called tadpoles, and represent the permanent, adult form of the salamanders. The mouth of tadpoles (Fig. 225, *A*) is small, almost minute, the lips armed with horny plates. They nibble dead leaves, while the mature animal has a very large mouth with teeth, and is carnivorous. The transformation of form of the mouth and digestive organs is as remarkable as in the butterfly.

Among the lower frogs are certain tropical forms, as *Alytes, Pelobates,* and *Pelodytes,* whose breeding habits are peculiar and interesting. The eggs of *Pelodytes* are deposited in small clusters in the water, those of *Pelobates* in a thick loop. The male of the European *Alytes obstetricans* winds a string of eggs which it takes from the female, and goes into the water, where it remains until the young (which have no gills) are hatched. The American *Scaphiopus,* or spade-footed toad, is not known to have this habit. This singular toad appears suddenly and in great numbers. It remains but a day or two in the water, where it lays its eggs in bunches from one to three inches in diameter. The tadpoles hatch in about six days after the eggs are laid; their growth is rapid, the young toads leaving the water in two or three weeks. The croaking of this toad is harsh, peculiar, and need not be confounded with that of any other species. As the spade-footed toads are rarely seen, it is possible that they burrow in the soil, like the European *Alytes.* Another peculiarity in the habits of *Alytes, Pelobates, Cultripes,* and *Pelodytes* is that they spawn at two seasons instead of one, and that their larvae attain a greater size than those of other frogs before completing their metamorphosis.

Among the tree-toads, *Polypedates* of tropical Western Africa, contrary to the usual habits of frogs, deposits its eggs in a mass of jelly attached to the leaves of trees which border the shore overhanging a pond. On the arrival of the rainy season, the eggs become washed into the pond below, where they develop. Our common piping tree-toad (*Hyla Pickeringii*), about the middle of April, in the Northern States, attaches her eggs singly to aquatic plants. The young are hatched in about twelve days.

Miss Hinckley has described the habits of the larger tree-toad (*Hyla versicolor*, Fig. 231). The eggs are attached from early May till July, singly and in small groups in grass which grows up and rests on the water. The tadpoles hatch in two days. In a week after the tadpoles appear the gills are absorbed. Meanwhile the tadpoles hang by their "holders," or suckers on the lips, to the leaves, as seen in the engraving. When about three weeks old the hind legs begin to bud out in front of the base of the tail. During the eighth week they take little food; the four legs grow out, the tail disappears, the mouth becomes adapted for seizing and eating insects, and they leave the water. This tree-toad depends for safety on its power of changing its color from green to gray; it hides among leaves, or in crevices in the bark of trees, when it becomes "like a part of the bark of the tree."

As an example of what is called a suppressed metamorphosis may be cited the case of a tree-toad in the island of Guadaloupe. There are no marshes on this island, consequently in a species of *Hylodes* the development of the young is direct; they hatch from the eggs which are laid under moist leaves, without tails, and are otherwise, except in size, like the adults. On the other hand, a tree-toad of the island of Martinique (*Hylodes Martinicensis*, Fig. 232) has tadpoles, which it carries on its back. The female of *Nototrema marsupiatum* of the Andes, has a sac on its back in which the young are carried. The *Notodelphys* of South America has similar habits; for example, the female (*Notodelphys ovifera*) has a dorsal sac a centimetre deep in which the eggs are carried. In the young of this and of *Gastrotheca*,



also of Central America. Peters found traces of external gills. The *Pipa*, or Surinam toad (*Pipa Americana*), which has no tongue, neither teeth in the upper jaw, has similar breeding habits. In this interesting toad the young are provided with small gills, which, however, are of no use to them, as the tadpoles do not enter the water, but are carried about in cavities on the back. The eggs are placed by the male on the back of the female. The female then enters the water; the skin thickens, rises up around each egg and forms a marsupial sac or cell. The young pass through their metamorphosis in the sacs, having tails and rudimentary gills; these are absorbed before they leave their cells, the limbs develop, and the young pass out in the form of the adult.

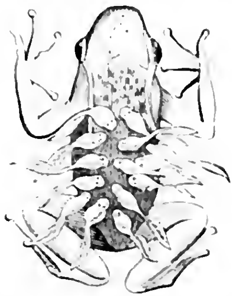


FIG. 232.—The Martinique Tree-toad carrying the young on its back.

The toad (*Bufo lentiginosus*) is exceedingly useful as a destroyer of noxious insects. It is nocturnal in its habits; is harmless, and can be taken up with impunity, though it gives out an irritant acrid fluid from the skin, which if transferred to the eye or lids occasions some pain. In the Northern States toads begin to make their peculiar low trilling notes from the middle to the 20th of April; from the latter date until the first of June they lay their eggs in long double strings, and the tadpoles are usually hatched in about ten days after the eggs are laid.

Of the true frogs (*Rana*) there are numerous species; of these the largest is the bull-frog, which makes a deep, hoarse, grunting noise. Smaller and more common species are the pickerel-frog and the marsh-frog. The frogs lay their eggs in roundish masses in ponds and pools from April to June, according to the latitude.

While most frogs are greedily devoured by herons and other large wading birds, as well as ducks and geese, and such species are only preserved from extinction by their nocturnal habits and their protective resemblance to the herbage and leaves of trees, there is a little bright red and blue frog in Nicaragua which hops about in bright daylight. It owes its life to its bad taste, for ducks and fowl will on this account not eat it.

CLASS VI.—REPTILIA (*Lizards, Snakes, Turtles, and Crocodiles*).

General Characters of Reptiles.—While the fishes and Amphibians are much alike, the reptiles, with their scales and claws, come near the birds. In their skull and skeleton, and in the 4-chambered heart of the crocodiles, they are also bird-like. Reptiles, then, are characterized by having their bodies covered with scales and their toes ending in claws, with the exception of the snakes, which have no legs and consequently no claws. The reptiles also, unlike the foregoing vertebrates, have true nostrils like those of birds and beasts, and there is in all except snakes an upper and a lower movable eyelid, while the tongue is long and forked and can be darted out after insects. They have also true lips, and a long windpipe like that of birds. There are 3000 species of living reptiles known, of which 358 are North American.

ORDERS OF REPTILES.

1. Body long, slender, cylindrical, limbless..... .... *Ophidia* (Snakes).
2. Body with a long tail; usually two pairs of limbs............. ....*Lacertilia* (Lizards).
3. Body enclosed in a thick shell.....*Chelonia* (Turtles).
4. Lizard-like; vertebræ hollow at each end...........................*Rhynchocephalia* (Sphenodon).
5. Body thick-scaled; teeth in sockets. *Crocodilia* (Crocodiles).

Order 1. *Ophidia* (Snakes).—Notwithstanding the fact that snakes have no legs, they can creep, glide, grasp, suspend themselves, erect themselves, leap, dart, bound, swim, and dive. The peculiar gliding motion of snakes is due to the movements of the large scales on the under side of the body. These are successively advanced, the hinder edges of the scales resting on the ground and acting as supports; resting on these the body is then drawn or pushed rapidly forwards.

Snakes can swallow animals much thicker than their own bodies, because the bones of their skull and throat separate so that the mouth and throat can be greatly extended. Thus a boa can swallow a calf whole, or a common striped snake can swallow a toad or bullfrog. The bones of the mouth are also armed with teeth pointing backwards, to prevent the prey from slipping out of the mouth. Snakes occasionally are known to hiss, the noise being caused by the passage of the breath from the lungs through the windpipe. The fixed, stony gaze of snakes is due to the fact that the eye is covered by a thin stationary lid, the true lids not being present.

The proverb "deaf as an adder" is not founded on fact, as snakes, like all reptiles, have internal ears. Their sense of hearing may be dull, but certain snakes, as the cobra de capello, are attracted by music.*

A few snakes are viviparous, as the vipers; others, as the common striped snake (*Eutænia sirtalis*), are ovoviviparous, the young developing in eggs, but hatching before the eggs are laid. This snake has been known to produce as many as 78 young ones.† When alarmed, a brood of young of this and other species have been known, since the days of Spenser, who refers to this habit in the "Faerie Queen,"

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* One remarkable characteristic of these dangerous serpents is their fondness for music. Even when newly caught they seem to listen with pleasure to the notes, and even to writhe themselves into attitudes. The Indian jugglers improve greatly on this instinct, and, after taming them by degrees, instruct them to keep time to their flageolet.—Percival, *Eng. Cyc. Nat. Hist.*

† *American Naturalist*, p. 1009, Dec., 1882

to enter the mouth of their parent, who swallows them and keeps them in her stomach until the danger is past.

Most snakes resemble in color the ground or soil they frequent; some being, as in the rattlesnake of the western plains, of the color of the soil in which they burrow; the little green snake is of the color of the grass through which it glides; others are dull gray or dusky, harmonizing with the color of the trunks of trees on which they rest. The poisonous coral-snake (*Elaps*) of the Central American forests is, however, gayly and conspicuously colored; indeed, it

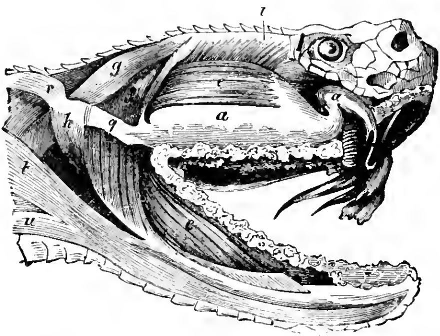

Fig. 233.—Head of the rattlesnake. *a a*, poison gland and its excretory duct; *e*, anterior temporal muscle; *f*, posterior temporal muscle; *g*, digastricus; *h*, external pterygoid muscle; *i*, middle temporal muscle; *q*, articulo-maxillary ligament which joins the aponeurotic capsule of the poison gland; *r*, the cervical angular muscle; *t*, vertebro-mandibular muscle; *u*, costo-mandibular muscle. After Duvernoy.

can afford to be brightly colored, as no birds dare to attack it.

The Salenoglyph poisonous snakes may always be recognized by their broad, flattened heads, and usually short, thick bodies. The poison gland of the rattlesnake (Fig. 233, *a*) is a modified salivary gland. The two fangs are modifications of maxillary teeth, each of which has been, so to speak, pressed flat, with the edges bent towards each other, and soldered together, so as to form a hollow cylinder open at both ends, the poison duct leading into the basal opening. When the fangs strike into the flesh, the muscles closing the jaws press upon the poison gland, forcing the poison into the wound. The poison-fangs are largest in the most deadly species, as the viper (*Vipera*), the puff adder (*Clotho*), the rattlesnake, and fer-de-lance (*Trigonocephalus*), but are small in the asps or hooded snakes (*Naja*). The bite of the rattlesnake is intensely painful; it is best cured by sucking, freely lancing, and by cauterizing the wound, and drinking large quantities (at least a pint) of whiskey or brandy, sufficient ordinarily to produce insensibility. Deaths from the bite of rattlesnakes are not common, while in India it is estimated that several thousand people annually die from the bite of the cobra—20,000 dying each year from the bite of snakes and the attacks of wild beasts.* The "rattle" of the rattlesnake is a horny appendage formed of buttonlike compartments; the sound made by the rattle, which has been compared by some to the stridulation of a Carolina locust, or of the Cicada, is an alarm note, warning the intruder; the rattle is sprung before the snake strikes. Allied to this snake is the copperhead (*Ancistrodon contortrix* Linn.) and the black mocassin (*Ancistrodon piscivorus* Linn.) In the water-snakes the tails are laterally compressed, while the poison-fangs are small. These snakes are not much over a metre in length, and live far from land in the East Indian seas.

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* In 1880 the deaths in India reported as from snake bite were 19,060; and 212,776 snakes were killed at a cost of over $1500 in rewards. The next year (1881) there were fatally bitten 18,610 people; and 254,968 snakes were destroyed at a cost of nearly $5000.

The snakes which do the mischief are, according to Fayrer, the cobra, the Bungarus cæruleus or krait, the echis, and the daboia or Russell's viper, all of which are most conspicuous snakes, and easily identified. There are others, such as Bungarus fasciatus, Ophiophagus elaps, which are dangerous, but comparatively rare, and seldom bite men; while the hydrophidæ, being confined to the sea or estuaries, are, though very poisonous, not so dangerous to man, and the trimeresuri, which are both uncommon and at the same time are not so deadly as to endanger life.

The poisonous snakes stand lowest in the series; they are succeeded by the striped snake, milk adder, and by the boas, which attain a length of five metres; while the anaconda grows eight metres long.

Order 2. Lacertilia.—Most lizards have cylindrical bodies, usually covered with small overlapping scales, with a long, slender tail, and generally two pairs of feet, the toes long and slender, and ending in claws. They run with great rapidity, and are active, agile creatures, adorned with bright metallic colors, in some cases green or brown, simulating the tints of the vegetation or soil on which they live; some are capable of changing their color at will, as in the chameleon and Anolis; this is due to the fact that the pigment cells (chromatophores) are under the influence of the voluntary nerves.

In many lizards (*Lacerta, Iguana,* and the Geckos), the middle of each caudal vertebra has a thin cartilaginous partition, and it is at this point that the tails of these lizards break off so easily when seized. In such cases the tail is renewed, but is more stumpy.

Both jaws are provided with teeth, while some have them developed on the bones of the mouth. The teeth are usually simple, sharp, conical, as in most lizards, including the Monitor, or they are flattened, blade-like, with serrated edges, as in the *Iguana,* or as in *Cyclodus* they are broad, adapted for crushing the food. Most lizards prey on insects; some live on plants. The eyelids are well-developed except in the Geckos, in which the lids are modified somewhat, as in the snakes, to form a transparent skin over the cornea of the eyes. The tongue is free and long, sometimes forked; in the iguana it ends in a horny point.

While the limbs are usually present, one or the other pair may in rare cases (in *Pseudopus* the fore feet are wanting; in *Chirotes* the hind feet are absent) be absent, or as in *Amphisbæna* and its allies the feet are entirely wanting.

Lizards lay their eggs in the sand or soil. The iguana or great lizard of the West Indies deposits hers in the hollows of trees. Certain kinds are viviparous.

Forming a connecting link between the lizards and the serpents is the glass-snake (*Opheosaurus*), whose body is very long, snake-like, and limbless, as is also the singular *Amphisbæna* of Brazil (Fig. 234) whose tail is nearly as broad

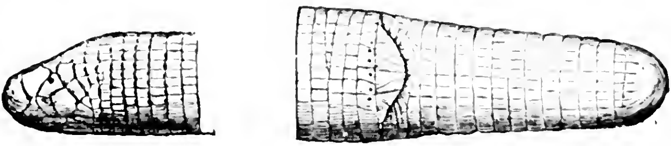


FIG. 234.—Head and tail of *Amphisbæna* From Lütken's Zoology.

as the head, and since the creature runs both backwards as well as forwards it is popularly supposed to be two-headed. It feeds on ants and other insects, and lives in or about ant hills.

The chameleons have the five toes arranged in two opposable groups adapted for grasping the twigs of trees;

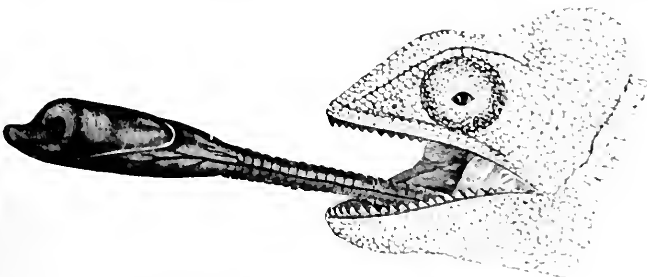


FIG. 235.—Tongue of Chameleon Natural size.

their eyes have a movable circular lid; they have remarkably long tongues (Fig. 235), which can be darted out five or six inches at insects, which adhere to the sticky swollen extremity while the body of the chameleon is perfectly immovable. Chameleons can change their color at will; as can the *Anolis* (Fig. 236) of Florida, which is a long smoothbodied lizard, which can change its color from a bright pea-green to a deep bronze-brown. The Gekko (Fig. 237, *Sphærodactylus*) has bulbous toes.

The horned toads (*Phrynosoma*, Fig. 238) are characteristic of the dry western plains; the body is broad, flattened, and spiny. Their color is like that of the soil they inhabit.

Fig. 236.—West Indian *Anolis*. From Lütken's Zoology.

Like all other lizards, the horned toads can withstand a long fast; they will in captivity eat insects and take milk.

Our most common lizard in the Middle and Southern States is *Sceleporus undulatus;* it is about six inches long, gray, with dark wavy bands, and may be seen in sunny glades running up the trunks of trees. The iguanas are very large, being nearly three feet in length, but rather sluggish lizards, with a dorsal row of high, thin spines. They are said to be excellent eating. A still larger form, resembling the iguanas, is the sea-lizard (*Amblyrhynchus*) of the Galapagos Islands, where it lives on the rocks by the shore, feeding on sea-weeds. The largest lizard of the West-

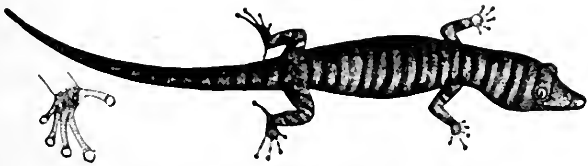


FIG. 237.—West Indian Gekko. From Lütken's Zoology.

ern Territories is the *Heloderma* or "Gila monster;" it is allied to the iguanas, but the body is heavily tuberculated. Its bite is poisonous. The largest of all existing lizards are the monitors, or species of *Varanus*, of Australia and the

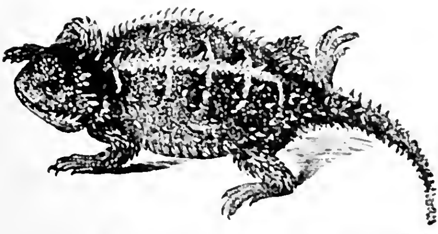


FIG. 238.—Horned Toad. From Lütken's Zoology.

East Indies, which nearly rival the crocodiles in size, being five or six feet in length.

Order 3. *Chelonia* (*Testudinata*, tortoises, turtles). These animals are at once recognized by their shell, the upper part forming the *carapace* and the lower the *plastron*; these two parts unite to form a case or box, within which the turtle can retract its head and limbs and tail.

There are about forty species of Chelonians in America north of Mexico. The lower forms of turtles are the marine species. Such is the great sea-turtle (*Sphargis coriacea*) of the Atlantic and Mediterranean, which is the larg-

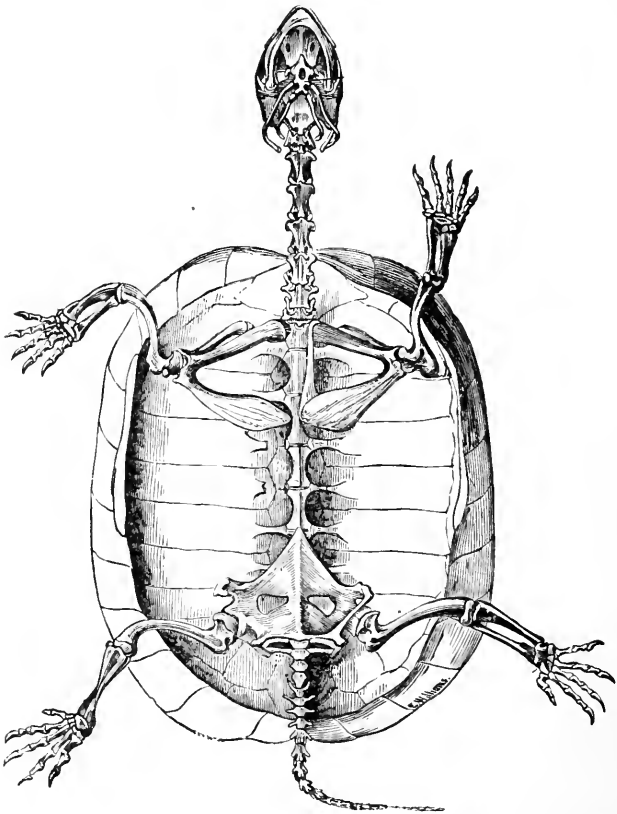


FIG. 239.—Skeleton of European Tortoise, with the plastron or under shell removed.

est of all existing turtles, and is sometimes eight feet long, weighing from eight hundred to twelve hundred pounds. Next to this species is the loggerhead turtle (*Thalassochelys caouana*), which is sometimes seen asleep in mid-ocean.

Still another is the hawk-bill or tortoise-shell turtle (*Eretmochelys imbricata*), the plates of whose shell is an article of commerce. The green-turtle of the West Indies weighs from two hundred to three hundred pounds, and is used for making delicious soups and steaks, being caught at night when laying its eggs on sandy shores. All the foregoing species have large, flat, broad flippers or fin-like limbs, while in the pond and river turtles the feet are webbed and the toes distinct. A very ferocious species is the common soft-shelled turtle (*Aspidonectes spinifer*), whose shell is covered with a thick leathery skin. It is carnivorous, voracious, living in shallow muddy water, throwing itself forward upon small animals forming its prey. The snapping-turtle (*Chelydra serpentina*) sometimes becomes five feet long; its ferocity is well-known; the flesh makes an excellent soup.

The terrapins belong to the genus *Pseudemys*; the pretty painted turtle (*Chrysemys picta*) is common in the Eastern States, while the *Nanemys guttatus*, or spotted tortoise, is black, spotted with orange. In the land tortoises the feet are short and stumpy. The *Testudo Indica* of India is three feet in length. The great land tortoises of the Galapagos Islands, the Mascarine Islands (Mauritius and Rodriguez), and also of the Aldabra Islands, lying northwest of Madagascar, are in some cases colossal in size, the shells being nearly two metres (six feet) in length. The fierce Mascarine species were contemporaries of the dodo and solitaire, and are now extinct.

The turtles lay their eggs in sand on the shores of ponds and rivers. In the Middle and New England States nearly all the turtles lay their eggs on or about June 10th, the eggs being hatched late in the summer. Turtles do not lay eggs until eleven to thirteen years old.

The land tortoises, as probably all turtles, are long-lived, and often reach a great age. White, in his "Natural History of Selborne," relates that one was kept in a village till it was supposed to be 100 years old.

Order 5. *Crocodilia.*—The crocodile, caiman, gavial, and alligator are the examples of this well-known group. They present a decided step in advance of other reptiles, the heart approaching that of birds, in having the ventricle completely divided by a partition into two chambers; the venous and arterial blood mingle outside of the heart, not in it, as in the foregoing orders. The brain is also more like that of birds. The nostrils are capable of closing, so that crocodiles and alligators draw their prey under the water and hold them there until they are drowned; but they are obliged to drag them ashore in order to eat them. The

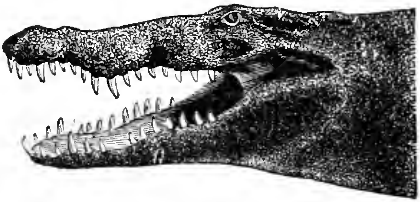


FIG. 240.—Head of the Florida Crocodile.

skin is covered with large bony, epidermal scales. The conical teeth are lodged in sockets in the jaws. The feet are partly webbed. The crocodiles and gavials lay from twenty to thirty cylindrical eggs in the sand on river banks. The crocodiles are distributed throughout the tropics, even Australia; the gavials are mostly confined to India and Malaysia, and also Australia. The group is represented in the Southern States by the alligator (*A. Mississippiensis*). It is nearly two metres (10–12 feet) long; while the Florida crocodile (*C. acutus*, Fig. 240) in which the jaws are much narrower, is over two and a half metres (14 feet) long. It inhabits the rivers of Florida, where it is very rare, and also the West Indies and South America. The cayman of Guiana belongs to a distinct genus, *Caiman*, and is characteristic of the rivers of tropical South America.

Class VII.—Aves (*Birds*).

General Characters of Birds.—The graceful, pleasing lines of the bird's body; its clothing of feathers; the toothless jaws encased with horn to form the bill, and the remarkable change of the fore-limbs into wings—these are the marks which separate the birds from other vertebrates. Besides this, they are warm-blooded, and their bones are compact and in many cases hollow, thus combining lightness with strength; hence birds are the most active and volatile creatures among all the back-boned animals. The vertebral column is so adapted that birds can fly in any direction, particularly in a vertical one; and it is the strength

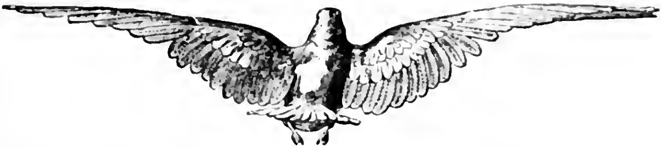


Fig 211.—Various curves of the wing of a bird at different points in its length. After Marey.

and flexibility of its spinal column that enables the lark to rise up and shoot high into the air. Birds can turn the head around and look directly back, as seen in the owls: this is owing to the unusually free articulation of the first neck-vertebra to the skull; thus the bird can reach every part of its body with its bill.

The most striking difference from other animals is in the modification of the fore-leg into a limb which supports a broad expanse of feathers, and ends in two rudimentary toe-bones. Another peculiarity in the skeleton connected with the power of flight is the very large breast bone, with its keel, which is very high and thin, serving for the attachment of the muscles of flight. Thus in all respects we see a complete adaptation of the bird's body to its life in the air. The wings are attached exactly at the highest part of the thorax, and hence when the outstretched wings act upon the air as a fulcrum all the weight of the body is placed below this surface of suspension (Marey). The flight of birds has been studied by Marey, who states that "from the manner in which the feathers of its wing lie upon each other, it is evident that the resistance of the air

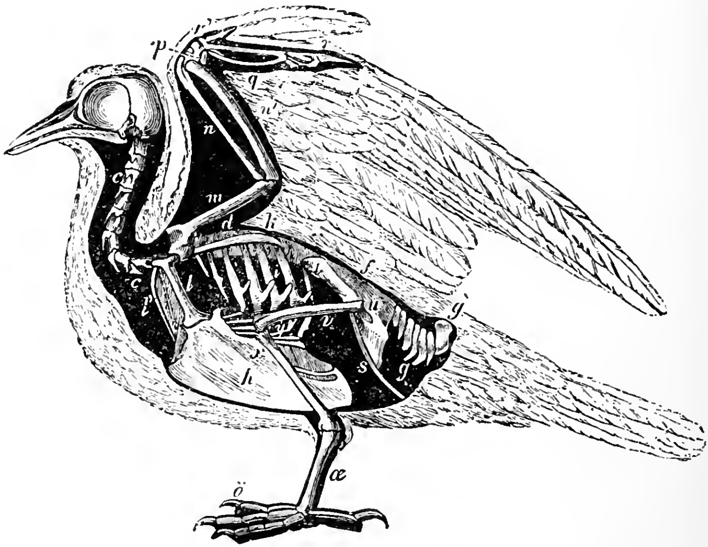
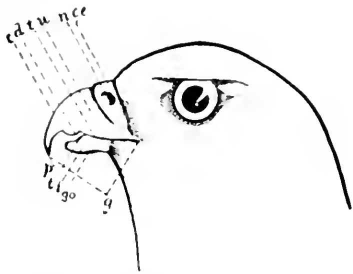
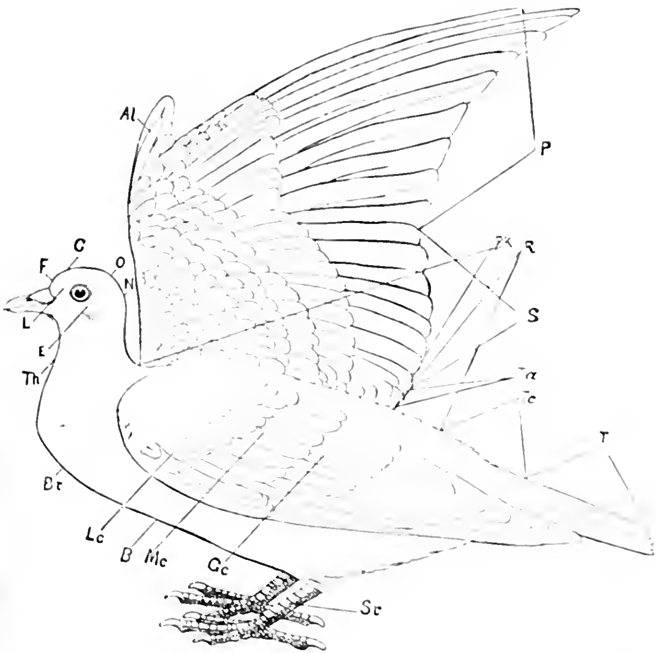


FIG. 242.—Skeleton and outline of the Dove. *c*, cervical vertebræ; *d*, dorsal vertebræ; *f*, lumbar vertebræ; *g'*, coccyx; *h*, breast-bone, sternum; *i*, ribs; *k*, shoulder blade, scapula; *l*, coracoid; *l'*, wish-bone, clavicles; *m*, humerus; *n*, ulna; *n'*, radius; *p*, carpus; *r*, metacarpals and three digits; *s*, ischiatic bone; *u*, pelvis; *t*, ilium; *v*, femur; *x*, tibia; *æ*, metatarsus; *ö*, digits. After Lütken.

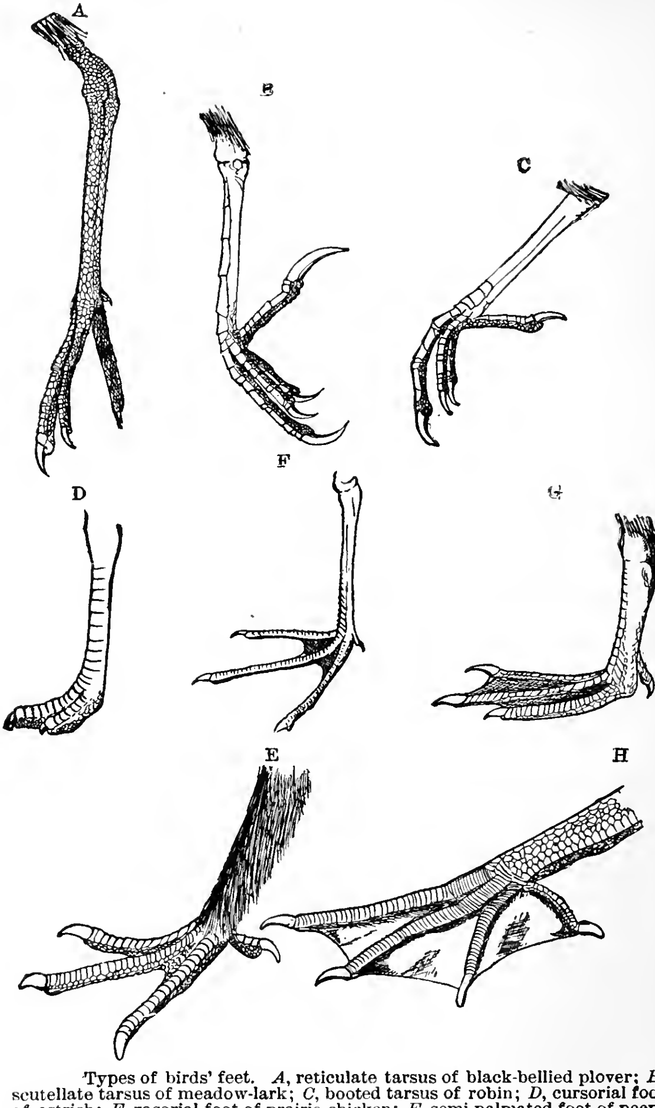
can only act from below upwards, for in the opposite direction the air would force for itself an easy passage by bending the long barbs of the feathers, which would no longer sustain each other." The wing acts on the air like a wedge or an inclined plane, "in order to produce a reaction against this resistance which impels the body of the bird upward and forward."



Head of a bird. *ce*, cere; *n*, nostril; *u*, upper mandible; *t*, tomia; *d*, tooth; *c*, culmen; *p*, tips of mandibles; *i*, under mandible; *go*, gonys; *g*, gape.



Topography of the Dove. *Al*, alula; *B*, belly; *Bk*, back; *Br*, breast; *C*, crown; *E*, ear; *F*, forehead; *L*, lore; *Gc*, greater coverts; *Lc*, lesser coverts; *Mc*, middle coverts; *N*, nape; *O*, occiput; *P*, primaries; *S*, secondaries; *R*, rump; *Sr*, scutellate and reticulate tarsus; *T*, tail; *Ta*, tertiaries; *Tc*, tail-coverts; *Th*, throat. *(To face page 200.)*



Types of birds' feet. *A*, reticulate tarsus of black-bellied plover; *B*, scutellate tarsus of meadow-lark; *C*, booted tarsus of robin; *D*, cursorial foot of ostrich; *E*, rasorial foot of prairie-chicken; *F*, semi-palmated foot of peep; *G*, totipalmate foot of wood-duck; *H*, of cormorant. (*To face page* 201.)

The power of remaining a long time in mid-air is increased by the large air-cells, which are pockets filled with air. There are nine of these air-sacs—three near the clavicle, four in the thorax, and two in the abdomen; they connect with the ends of some of the air-tubes, and also with the hollows of the bones, so that the bird's body is lightened and buoyed up by air.

The most striking external feature of birds is the presence of feathers; no reptile on the one hand, or mammal on the other, is clothed with feathers, though the scales on the legs and feet of birds are like those of reptiles, and it should be borne in mind that feathers are only modified scales or hairs. The ordinary feathers are called *pennæ* or contour feathers, as they determine by their arrangement the outline of the body. They are, like hairs, developed in sacs in the skin; the quill is hollow, partly imbedded in the skin; this merges into the shaft, leaving the outgrowths on each side called *barbs*, which send off secondary processes called *barbules*. The barbules and hooklets are commonly serrated, and end in little hooks by which the barbules interlock. Down is formed of feathers with soft, free barbs called plumules.

Over the tail-bone (*coccyx*) are usually sebaceous glands, which secrete an oil, used by the bird in oiling and dressing or "preening" its feathers. In some birds, as the cock and turkey, the head and neck are ornamented with naked folds of the skin called "combs" and "wattles."

The sense of sight, smell, and hearing are acute in birds, particularly that of sight. Birds have three eyelids, besides an upper and lower lid, a membrane which can be drawn over the eye, and is called the "nictitating membrane." This covers the whole front of the eye-ball like a curtain. With this it is said the eagle can look directly at the sun. The eyes of hawks and eagles are provided with a ring of bony plates occupying the front of the sclerotic. By means of this ring the eye can adjust itself like a telescope so as to take in both near and distant objects. The penguin also is endowed with this apparatus, which enables it to adjust its eye to see above and under the water.

Though birds (except the night-birds, especially the owls) have no external ear, they can hear well; otherwise what would be the use of thei. powers of song?

The eggs of birds are, with the exception of those of lizards, enormous in proportion to those of other vertebrate animals. The largest egg known is that of the *Æpyornis*, an extinct bird of Madagascar, which is about a third of a metre ($13\frac{1}{2}$ inches) in length. Birds lay but few eggs, and the young of those which build nests when hatched are blind, naked, unable to walk, and are fed by the parent birds. In the fowls, such as the hen and partridge, in the wading birds as well as the ducks and other swimming birds, the young, on breaking from the shell, walk or swim and pick up their own food.

At the close of the breeding season birds moult their feathers; but some birds moult twice and thrice. The quill-feathers are usually shed in pairs, but in the ducks they are shed at once, so that these birds do not at this time go on the wing, while the males put off the highly colored plumage of the days of their courtship, and assume for several weeks a dull attire. In the ptarmigan both sexes not only moult after the breeding season is over into a gray suit, and then don a white winter suit, but also wear a third dress in the spring. In the northern hemisphere the males of many birds put on in spring bright, gay colors. Other parts are also shed; for example, the thin, horny crests on the beak of a western pelican (*Pelicanus erythrorhynchus*), after the breeding season, are shed like the horns from the head of deer. Even the whole covering of the beak and other horny parts, like those about the eyes of the puffin, may also be regularly shed.

As a rule, male birds are larger and have brighter colors, with larger and more showy combs and wattles, than the females, as seen in the domestic cock and hen; and the ornamentation is largely confined to the head and the tail, as seen especially in male humming-birds. Sometimes, however, both sexes are equally ornamented, and in rare cases the female is more highly colored than the male; she is sometimes also larger, as in most birds of prey. There is little doubt that the bright colors of male birds render them more conspicuous and to be more readily chosen by the females as mates, for in birds, as in higher animals, the female may show a preference for or antipathy against certain males. Indeed, as Darwin remarks, whenever the sexes of birds differ in beauty, in the power of singing, or in producing what he calls "instrumental music," it is almost invariably the male which excels the female.

The songs of birds are doubtless in part love-notes, though birds also sing for pleasure. The notes of birds express their emotions of joy or alarm, and in some cases at least the calls of birds seem to convey intelligence of the discovery of food to their young or their mates.* They have an ear for music; some species, as the mocking-bird, will imitate the notes of other birds. The songs of birds can be set to music. Mr. X. Clark has published in the *American Naturalist* (vol. xiii. p. 21) the songs of a number of our birds. The singular antics, dances, mid-air evolutions, struts, and posturings of different birds, are without doubt the visible signs of emotions which in other birds find vent in vocal music.

The nesting habits of birds are varied. Many birds, as

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* "It is necessary in a philosophical spirit to regard every sound made by a bird under the all-powerful influence of love or lust as a 'song.' It seems impossible to draw any but an arbitrary line between the deep booming of the emeu, the harsh cry of the guillemot (which when proceeding from a hundred or a thousand throats strikes the distant ear in a confused murmur like the roar of a tumultuous crowd), the plaintive wail of the plover, the melodious whistle of the widgeon, the 'cock's shrill clarion,' the scream of the eagle, the hoot of the owl, the solemn chime of the bell-bird, the whip-cracking of the manakin, the chaffinch's joyous burst, or the hoarse croak of the raven, on the one hand, and the bleating of the snipe or the drumming of the ruffed grouse on the other." (A. Newton.)

the gulls, auks, etc., drop their eggs on bare ground or rocks; as extremes in the series are the elaborate nests of the tailor-bird, and the hanging nest of the Baltimore oriole, while the woodpecker excavates holes in dead trees. As a rule, birds build their nests concealed from sight; in tropical forests they hang them, in some cases, out of reach of predatory monkeys and reptiles. Birds may change their nesting habits sufficiently to prove that they have enough reasoning powers to meet the exigencies of their life. Parasitic birds, like the cuckoo and cow-birds, lay their eggs by stealth in the nests of other birds. "Some of the swifts secrete from their salivary glands a fluid which rapidly hardens, as it dries on exposure to the air, into a substance resembling isinglass, and thus furnish the 'edible bird's nests' that are the delight of Chinese epicures. In the architecture of nearly all the Passerine birds, too, some salivary secretion seems to play an important part. By its aid they are enabled to moisten and bend the otherwise refractory twigs and straws and glue them to their place. Spiders' webs also are employed with great advantage for the purpose last mentioned, but perhaps chiefly to attach fragments of moss and lichen so as to render the whole structure less obvious to the eye of the spoiler. The tailor-bird deliberately spins a thread of cotton and therewith stitches together the edges of a pair of leaves to make a receptacle for its nest. . . . . In South America we have a family of birds (*Furnariidæ*) which construct on the branching roots of the mangrove globular ovens, so to speak, of mud, wherein the eggs are laid and the young hatched. . . . . The females of the hornbills, and perhaps of the hoopoes, submit to incarceration during this interesting period, the males immuring them by a barrier of mud, leaving only a small window to admit air and food, which latter is assiduously brought to the prisoners." (Newton.)

The duties of incubation are, as a rule, performed by the female, but in most Passerine birds and certain species of other groups, the males divide the work with the females, and in the ostrich and other *Ratitæ* the labor is wholly performed by the males.

There are probably from 7000 to 8000 species of living birds. Of the whole number, 878 distinct species or well-marked geographical races inhabit North America north of Mexico and including Greenland. The geographical distribution of birds is somewhat complicated by their migrations. While the larger number of species are tropical, arctic birds are abundant, though most of them are aquatic. In the United States there are three centres of distribution: (1) the Atlantic States and Mississippi Valley; (2) the Rocky Mountain plateau, and (3) the Pacific coast.

Nearly all the birds which breed in the central and northern portions of the United States migrate southward in the autumn, and spend the winter in the warmer Southern States or in Central America or the West Indies. The causes of this regular annual migration are pr bably due to the changes of the season, and to the want of food in the winter time, and also to the breeding habits of birds. Tropical birds which breed at home do not migrate to other climes; but some Brazilian species migrate southwards into Buenos Ayres; it is those birds which live far north which have what is called the "migratory instinct." Birds migrate by night as well as by day; and the young return the following spring to their birthplace.

In North America* the birds of the Western plains and of the Rocky Mountains as well as of the Pacific coast are sedentary, or migrate but a short distance. It is the eastern birds which migrate regularly. These pass southwards into Mexico and Guatemala, and reach South America. Thus the extent of the migration varies greatly, some species only going a few degrees north and south, while others migrate annually from arctic America to the tropics, and every gradation occurs between these extremes. Among those which migrate farthest are the species of warblers

* See the writings of Baird, Allen, and Wallace.

(*Dendrœca*), and other fly-catching warblers (*Mniotiltidæ*), many of which breed on the shores of Hudson's Bay, and spend the winter in Mexico or the West Indies. More species of birds breed in Canada than in the warm Southern States. Birds have been known to extend their range of migrations; the rice-bird or bobolink continually widens its range as rice and wheat are more extensively cultivated. This bird winters in Cuba and other West Indian islands, and probably also in Mexico. In April it enters the Southern States and passes northward, till in June it reaches Canada and extends west to the Saskatchewan River in 54° north latitude.

Says Baird: "While birds proceed generally in the spring to the very spot of birth, and by a definite route, their return in autumn is not necessarily in the same line. Many birds are familiar visitors in abundance in certain localities in either spring or autumn, and are not known there in the other season." He thinks that in very many instances birds proceed northward along the valley of the Mississippi, to return along the coast of the Atlantic. In general, also, the northward vernal movement is performed much more rapidly, and with fewer stops by the way, than the autumnal. "Birds generally make their appearance in given localities with wonderful regularity in the spring—the *Sylvicolidæ* especially; a difference of a few days in successive years attracting the notice of the careful observer: this difference is generally influenced by the season. The time of autumnal return is, perhaps, less definite." (Baird.)

While there are a number of very strange extinct birds, one of which called the *Archæopteryx* is the connecting link between reptiles and birds, and there are fossil birds with teeth, all the living species belong to two single sub-classes.

SUB-CLASSES OF EXISTING BIRDS.

1. Sternum smooth; wings rudimentary......*Ratitæ* (Ostrich).
2. Sternum keeled; wings well developed....*Curinatæ* (Robin, etc.).

SUB-CLASS I.—RATITÆ.

General Characters of Running Birds.—The kiwi-kiwi, the moa, cassowary, and ostrich differ from other birds in the smooth, unkeeled sternum and the short tail; the wings are rudimentary and the hind legs strong, these birds (ex-

FIG. 243.—Moa, *Palapteryx*, with three Kiwi-kiwi birds.

cept *Apteryx*) being runners, and either of large or, as in the extinct forms, of colossal size.

The simplest form is the "kiwi-kiwi" or *Apteryx* of New Zealand (Fig. 243), of which there are three or four species. It is of the size of a hen, with a long slender beak, the nostrils situated at the end of the upper jaw, while the body is covered with long hairy feathers. The female lays only a single large egg, which weighs one quarter as much as the bird itself, in a hole in the ground. It is a night bird, hiding by day under trees.

The giant, ostrich-like, extinct birds of New Zealand, called *moa*, and represented by several species, chiefly of the genera *Dinornis* and *Palapteryx* (Fig. 243), were supposed to have been contemporaries of the Maoris or natives of New Zealand. While a fourth toe is present in the *Apteryx*, the moa-bird has only three toes.

Fig. 241.—Rudimentary wing of the Emeu. From Lütken's Zoology.

The largest of the moas, *Dinornis giganteus*, stood nearly three metres ($9\frac{1}{2}$ feet) in height, the tibia or shin-bone alone measuring nearly a metre (2 feet 10 inches) in length. These moa birds belong to three genera: *Dinornis* with ten, *Palapteryx* with three, and *Aptornis* with a single species.

Allied to the moa was a still larger bird, the *Æpyornis maximus* of Madagascar, supposed by some to be the roc of the Arabian Nights' Tales. Of this colossal bird, remains of the skull, some vertebræ, and a tibia 64 cent. long, have been found. The single egg discovered is of the capacity of one hundred and fifty hen's eggs.

Here also belong the three-toed cassowaries of the East Indies and Australia, and the emeu (Fig. 244) of Australia; both of these birds are about 2 metres (5–7 feet) high. The South American ostrich (*Rhea Americana*, Fig. 245), with three toes to each foot, is a smaller bird, standing 1.3 metres high, running in small herds on the pampas. The two-toed ostrich (*Struthio camelus*), of the deserts of Africa and Arabia, now reared for the feathers of its wings and tail, so valuable as articles of commerce, is the largest bird now living, being 2–2.7 metres (6–8 feet) high. It can outrun a horse, and lives in flocks. It lays about thirty large white eggs in a nest in the sand; they are covered in the daytime by the hen or left exposed to the sun, while at night the male sits over and guards them. In Cape Colony ostrich-culture has become an important business; in 1865 there were only eighty individuals on the ostrich farms; in 1875 there were 32,247 ostriches, either free or in parks where Lucerne grass is cultivated as food for these useful birds. The South American ostrich is in Patagonia hunted

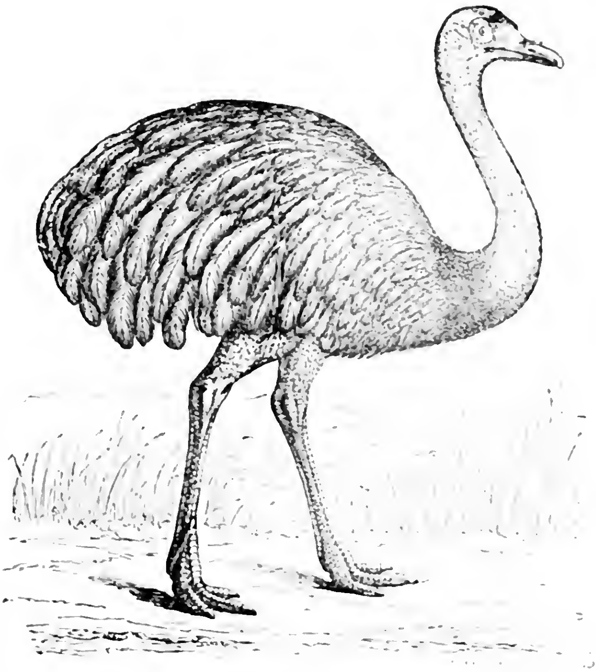

FIG. 245.—South American Ostrich. From Lütken's Zoology.

for its feathers. According to Herbert Smith, its food consists of seeds, grass, insects, etc., and the herdsmen say that it also eats snakes. "The nest is a mere shallow hole scratched in the ground; twenty, thirty, or more eggs are found together, but it appears that these are not all laid by one bird; several females lay their eggs together, and take turns in sitting on them. The nest may be left uncovered during the heat of the day, but in this region (Buenos Ayres), I believe, it is never entirely deserted. (*American Naturalist*, July, 1883.)

Orders of Carinate Birds.

1. Wings small and short; diving birds............. *Pygopodes.*
2. Wings long, pointed; rapid fliers; anterior toes webbed....................................... *Longipennes.*
3. Feet wholly webbed, including the inner toe..... *Stegopodes.*
4. Bill lamellate, *i.e.*, both mandibles with teeth-like projections.................................. *Lamellirostres.*
5. Wading birds; the leg long and naked above the heel; bill usually long and slender......... ... *Grallatores.*
6. Land birds; four toes, three in front, one behind; tibiæ often spurred........................... *Gallinæ.*
7. Toes like the foregoing; the bill horny and convex at tip.. *Columbæ.*
8. Bill cered, hooked, and large; feet large, not yoke-toed .... *Raptores.*
9. Feet yoke-toed; bill stout, and strongly hooked... *Psittaci.*
10. Toes often in pairs, two in front and two behind; wings with ten primaries...................... *Picariæ.*
11. Perching and singing birds; feet adapted for grasping; hind toe opposed to the others....... *Passeres.*

Sub-Class I.—Carinatæ.

General Characters of Carinate Birds.—All other living birds belong to this group; they are remarkably homogeneous in form and structure. They are characterized by the keeled breast-bone or sternum—the wings, as a rule, being well developed.

Order 1. *Pygopodes* (Diving birds).—These are eminent as swimmers, and comprise the penguins, auks, puffins, grebes, and loons. The penguins (Figs. 246, 247) are confined to the antarctic regions. They are large birds, and form a characteristic element in a Patagonian landscape. The bones are solid, not light and hollow, as in other birds; the wings are small, paddle-like, with scale-like feathers;

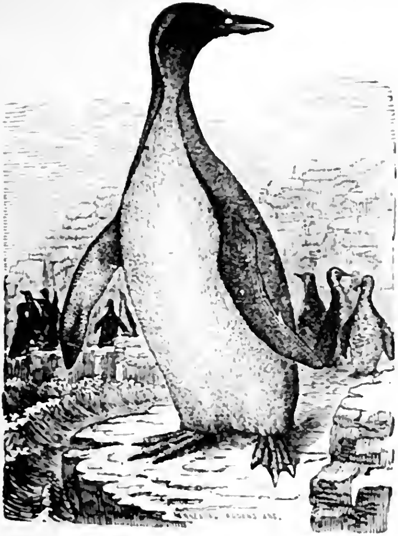

FIG. 246.—King Penguin. From Lütken's Zoology.

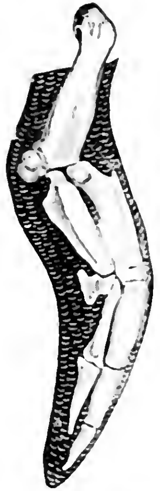

FIG. 247.—Wing-bones of Penguin. From Lütken.

FIG. 248.—Black Guillemot. From Nordenskiöld

FIG. 249.—Arctic Puffin From Nordenskiöld

on shore they have an awkward gait. They lay but a single egg, and some species do not lay their egg on the rocks, but bear it about in a pouch-like abdominal fold. The penguins, however, differ so much from the other divers that they are now often ranked as a separate group called

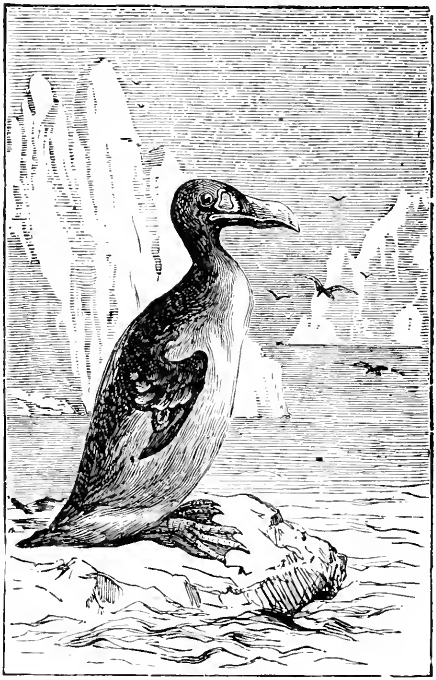

FIG. 250.—The Great Auk.

Sphenisci. There are twelve species of penguins, divided among three or four genera.

The guillemots (Fig. 248, *Uria grylle*), auks, and puffins (Fig. 249, *Fratercula arctica*) are characteristic arctic birds, ranging from Labrador northward, and have great powers of flight. The gare fowl, or great auk (*Alca impennis,*

Fig. 250), is nearly or quite extinct, being until lately confined to one or two inaccessible islets near Iceland, where it has been extinct since 1844, and to Labrador, though formerly it ranged from Cape Cod northward, a few survivors having lived on the Funks, an islet on the eastern coast of Newfoundland, within perhaps thirty years.

The grebes have lobate feet, and the tail is a mere tuft of downy feathers. They lay a greater number of eggs (6–8) than in other birds of this order. The nest is formed of matted vegetation, close to the water, or, as it is said, floating among aquatic plants. The young swim as soon as they are hatched. These birds inhabit the lakes and rivers of all parts of the earth. The pied-billed grebe (*Podilymbus podiceps*) is common in the United States in the winter.

FIG 251.—Roseate Tern.

The loons are well known for their large size, flat bodies, long necks, and quickness in diving. They are migratory, and lay two or three eggs in rushes near the water's edge. Their voice is extremely loud and harsh. The great northern diver (*Colymbus torquatus*), which tenants our lakes and bays, is 2½–3 feet in length; it is black and white, the head and neck iridescent with violet and green; while the red throated diver (*C. septentrionalis*) is smaller, with a large chestnut-red patch on the throat.

Order 2. *Longipennes* (Long-winged swimmers).—The petrels, gulls, and terns represent this group. They have long, slender, compressed bills, long, sharp wings, immense powers of flight, and lay their eggs in rude nests on rocks or upon the ground. The petrels, or "Mother Carey's Chickens," belong to the genus *Thalassidroma*, and are remarkable for their small size and slight bodies; they are ever on the wing, far out at sea following in the wake of vessels for food, and breed in holes in the ground. The terns are known by their very long, stout beaks. They lay from one to three eggs in a hollow in the ground. They are noisy, with shrill voices, and, like gulls, are gregarious. The common tern or sea-swallow (*Sterna hirundo*) has a red bill, while the roseate tern (*S. paradisæa*, Fig. 251) has

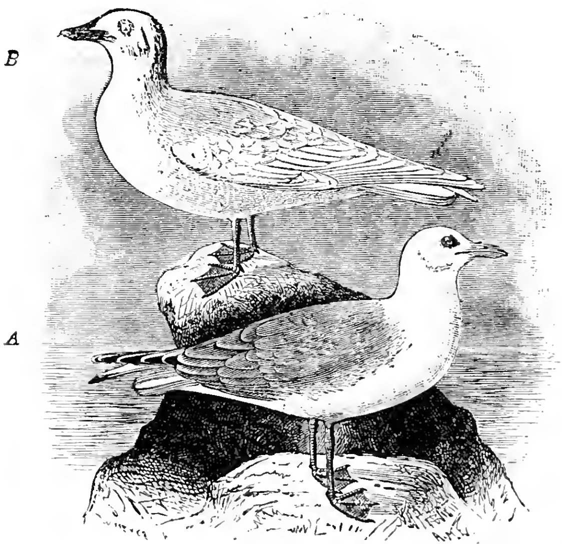

Fig. 252.—*A*, Kittiwake Gull; *B*, Ivory Gull. From Nordenskiöld.

a black bill, and the body is rosy beneath. The gull family have larger bodies and feet, and the wings shorter than in terns. They occur on all sea-coasts and inland lakes (Fig. 252). The skuas (Fig. 253) have habits like those of gulls. The most notable member of the group of petrels is the albatross (*Diomedea exulans*) of the Southern hemisphere. Its wings expand more than three metres (nearly ten feet). It lays a single egg 12 cm. long, and spends most of its life on the ocean far away from land. The sooty albatross (*D. fuliginosa*, Fig. 254) is occasionally seen on the Pacific coast.

Order 3. Steganopodes (Totipalmate birds).—The gulls are

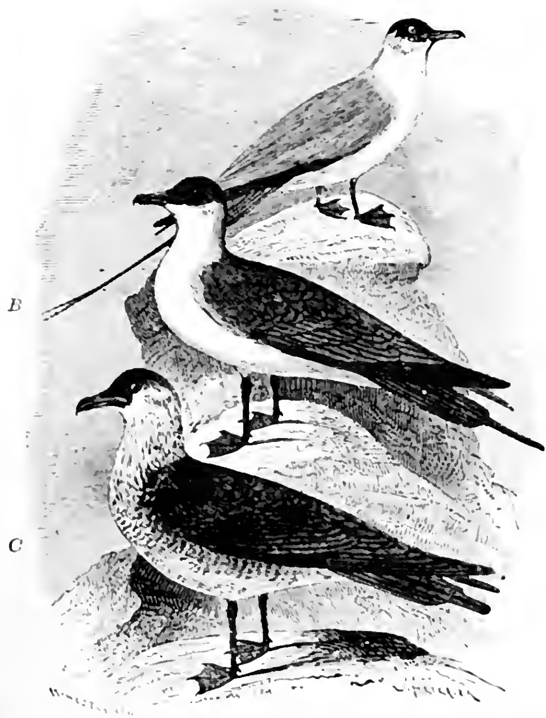

FIG. 253.—*A*, Common Skua; *B*, Buffon's Skua; *C*, Pomarine Skua. From Nordenskiöld.

succeeded in the ascending series by the tropic-bird, frigate or man-of-war bird, the darter or snake-bird, the cormorants, pelicans, and gannets, in which all four toes are fully webbed, the web reaching to the tips of the toes. The body, especially in the pelicans and gannets, is buoyed up more than in other birds by a large number of much subdivided air-cells under the skin of the body.

The pelican is remarkable for the large, loose pouch on the under jaw, capable of holding several quarts, or several hundred small fishes. In the East Indies, pelicans are tamed and used by the natives in fishing, as is the cormorant in China, while in early times it was in England.

The cormorants are very gregarious, and breed in great numbers in the northern regions on cliffs overhanging the

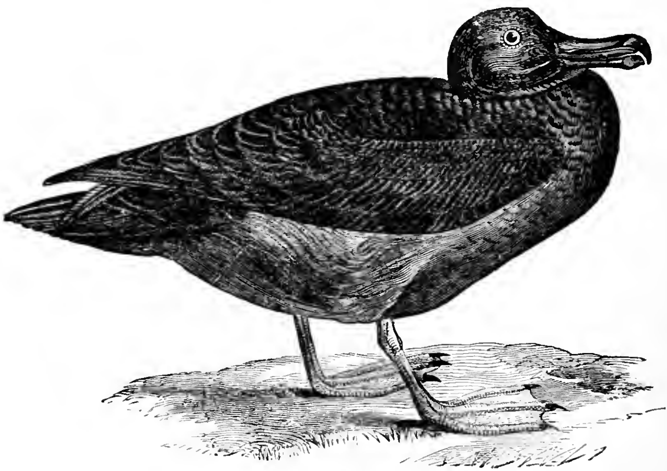

FIG. 254.—Sooty Albatross.

sea. Their nests are rude and bulky. They feed mainly upon fish, and are notoriously voracious. The common cormorant or shag (*Graculus carbo*) breeds in great numbers in Labrador and Newfoundland. It is glossy greenish black in summer, with numerous white plumes on the head and neck.

The darter, snake bird, or anhinga (*Plotus anhinga*) is common in the South Atlantic and Gulf States; it has a long snake-like neck, and can swim a long distance under water. The gannet or solan goose (*Sulabassana*) breeds in countless numbers in the Magdalen Islands in the Gulf of St. Lawrence. It resembles a goose in shape. In fishing

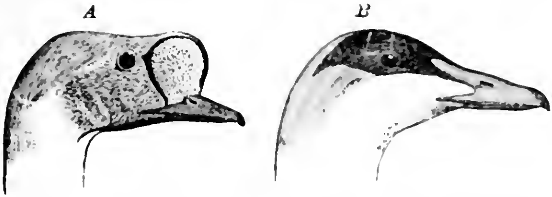

FIG. 255.—*A*, King Duck; *B*, Eider Duck. From Nordenskiöld.

it plunges from a great height, remaining under the water for a few seconds.

Order 4. *Lamellirostres* (Ducks and Geese).—These birds have usually broad bills furnished with lamellate, teeth-

FIG. 256.—Summer Duck.

like projections. The feet are palmated, adapted for swimming rapidly. In the mergansers the bill is narrow and more strongly toothed. The eider duck (*Somateria mollissima*, Fig. 255, *B*) breeds from Labrador around northward to Scotland; it plucks it down from its breast, building with it a large loose warm nest under low bushes on the sea-coast, where it lays three or four pale, dull green eggs. With it is associated the rare king eider (*Somateria spectabilis*, Fig. 255, *A*). The canvas-back (*Fuligula vallisneria*) feeds, as its specific name implies, on the wild celery (*Vallisneria*) on the middle Atlantic coast in winter, whence it derives its delicious flavor. The summer duck (*Aix sponsa*, Fig. 256) breeds in trees. The original source of our domestic duck is the mallard, or *Anas boschas*. It is known

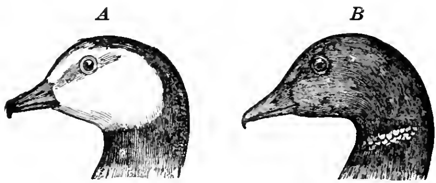

FIG. 257.—*A*, Barnacle Goose; *B*, White-fronted Goose. From Nordenskiöld.

to cross with various other species. Upward of fifty kinds of hybrid ducks are recorded, some of which have proved to be fertile. The black duck (*Anas obscura*) is abundant on the shores of North-eastern America, and is frequently brought into the market. The wild goose (*Branta Canadensis*) breeds in the Northern United States and in British America. While it usually breeds on the shores of rivers, it has been known in Colorado and Montana to nest in trees. Allied to it is the barnacle goose of Europe (*Branta leucopsis*, Fig. 257, *A*), which very rarely occurs in this country; also the white-fronted goose (Fig. 257, *B*), is an arctic bird. The swans are characterized by their long necks, the trachea or wind-pipe being remarkably long, especially in the trumpeter swan, where

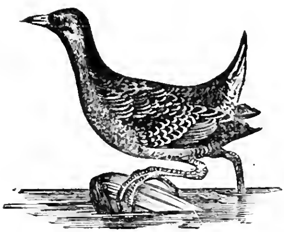

FIG. 258.—Carolina Rail.

it enters a cavity in the breast-bone, makes a turn and terminates in the lungs, after forming a large coil.

To this group, or next to it, also belong the flamingoes, the American flamingo (*Phœnicopterus ruber*) occurring on the Florida and Gulf coast. Its feathers are scarlet, its bill yellow, large and thick, while the legs and neck are of great length. It connects the swimming with the wading birds. The foregoing group forms a division called the *Natatores* or swimming birds.

Order 5. Grallatores (Wading birds).—These have long,

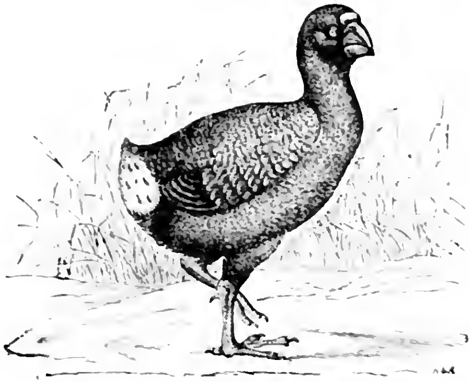

FIG 259.—*Notornis*. From Lütken's Zoology.

naked legs, and therefore long necks, with usually remarkably long bills. They are divided into cranes, rails, etc. (*Alectorides*), the herons and their allies (*Herodiones*), and the shore-birds, snipes and plovers, or *Limicolæ*.

In the cranes, together with rails (*Porsana Carolina*, Fig. 258), the toes are often long, and in some forms, such as the coots and gallinules, which have lobate feet, there is an approach to the ducks. The coot (*Fulica Americana*) connects the swimming with the wading birds. The bill is much as in the gallinules, but the toes are lobate, having large semicircular membranous flaps; hence they can swim like the grebes.

The purple gallinule (*Porphyrio martinica*) has the head, neck, and under parts of a beautiful purplish blue, becoming darker on the belly. It inhabits the South Atlantic and Gulf States. With it is associated the Florida gallinule (*Gallinula galeata*). Allied to *Porphyrio* is the New Zealand *Notornis* (Fig. 259).

Allied to the gallinules is the "giant" or *Gallinula gigantea* (Fig. 260), which formerly lived in the Mascarene Islands, having been observed as late as 1694. It stood two metres (over six feet) high. With it was associated a large blue gallinule—*Porphyrio* (*Notornis?*) *cærulescens*—which was last seen on the Isle Bourbon between 1669 and 1672. It was incapable of flight, but ran with exceeding swiftness.

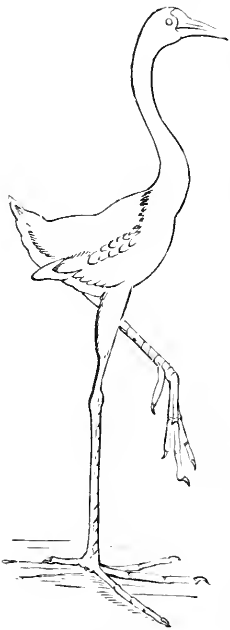

Fig. 260.—The "Giant" of Mauritius.

The cranes are of great stature, the legs and neck very long, with the head sometimes curiously tufted. The white or whooping crane (*Grus Americanus*) is pure white, and is about 50 inches long, while the brown or sandhill crane (*Grus Canadensis*) is smaller and the adult plumage is leaden gray. With the true herons are associated the night herons and the bitterns of the United States, the boat-billed heron of Central America, and the odd *Balæniceps rex* of Africa, which has an enormous head and broad, large bill. The American bittern (*Botaurus lentiginosus*) nests on the ground. The night heron or squawk (*Nyctiardea grisea*) is common in summer in the Northern States; it is about two feet in length and has two very long plumes arising from the base of the head. The great blue heron (*Ardea herodias*) is about four feet in length, and the general color above is grayish blue.

The herons are succeeded by the singular spoon-bills, represented by the roseate spoon-bill (*Platalea ajaja*), and which, with the wood Ibis and other species of this group, adorn the swamps and bayous of the South Atlantic and Gulf States.

The shore-birds, or the curlews (*Numenius longirostris*, Fig. 261), plover, sandpipes, peeps, snipes (*Gallinago Wilsonii*, Fig. 262), woodcock, and stilt (*Himantopus nigricollis*, Fig. 263), are long-legged, long-billed birds, going in flocks by the seashore or river-banks, sometimes living inland on low plains; they are not, generally speaking, nest-

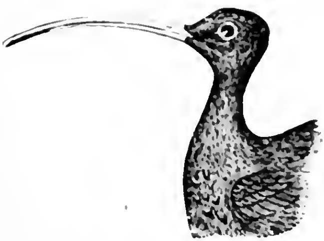

FIG. 261.—Long-billed Curlew.

FIG. 262.—American Snipe.

builders, the eggs being laid in rude nests or hollows in the ground. They feed on worms, insects, and snails, either picking them up from the surface or boring for them in the mud or sand, or forcing the vermian food out of their holes by stamping on the ground. The American snipe (*Gallinago Wilsonii*, Fig. 262) has the bill much longer than the head, perfectly straight, soft to the end, where it is somewhat widened and grooved on top; it is 9–11 inches long; it lives in open, wet places, and is migratory. In the American woodcock (*Philohela minor*) the bill is much longer than the head, stout and deep at base, grooved nearly its whole length, the tip knobbed. It is 30 cm. (11 to 12 inches) long, and frequents bogs, swamps, wet woodlands and fields in the eastern United States and Canada.

Connecting in some degree the waders and gallinaceous fowl are the bustards of the Old World, certain strange exotic birds; especially the horned screamers, represented by a very rare bird, the *Palamedea cornuta,* which has sharp horns on the wings.

Order 6. *Gallinæ* (Gallinaceous birds).—The appearance

FIG. 263.—Stilt.

of these birds, formerly called *Rasores,* from their peculiar habit of scratching the ground for food, is readily recalled by a simple enumeration of the partridge, Oreortyx (*O. pictus,* Fig. 264), quail (*Ortyx*), ptarmigan (*Lagopus,* Fig. 265), pinnated grouse or prairie hen (*Cupidonia cupido*), sage-cock, Canada grouse or spruce partridge (*Tetrao*), and wild turkey (*Meleagris*), as well as the exotic forms, the pheasant of the Old World, the useful hen or barn-yard fowl, which is a descendant of the jungle fowl (*Gallus Bankiva*) of India. These are allied to the argus-pheasant and the peacock of Malaysia, the latter rivalling the humming-birds in its gorgeous plumage. The guinea-hen is an African bird. To this group belong the curious mound birds.

The mound-birds, says Wallace, are a small family of birds, some of them smaller than a hen, found chiefly in Australia and the surrounding islands, and extending as far as the Philippines and northwest Borneo. They are allied to the gallinaceous birds, but differ from these and from all others in never sitting upon their eggs, which they

FIG. 264.—Californian Plumed Partridge.

bury in sand, earth, or rubbish, and leave to be hatched by the heat of the sun or of fermentation. They are all characterized by very large feet and long curved claws, and most of the species of *Megapodius* rake and scratch together all kinds of rubbish, dead leaves, sticks, stones, earth, rotten wood, etc., till they form a large mound, often six feet high and twelve feet across, in the middle of which they bury their eggs. A number of birds are said to join in making these mounds and to lay their eggs together, so that forty or fifty eggs may be found. Allied to the mound-birds is the maleo (*Megacephalon rubripes*). They scratch holes in sand three or four feet deep in the beaches of the Celebes Islands, the birds going down for this purpose ten or fifteen miles from the interior; and returning again, leaving the eggs to hatch and the young to shift for themselves. (Wallace.)

The megapods, together with the American guans and

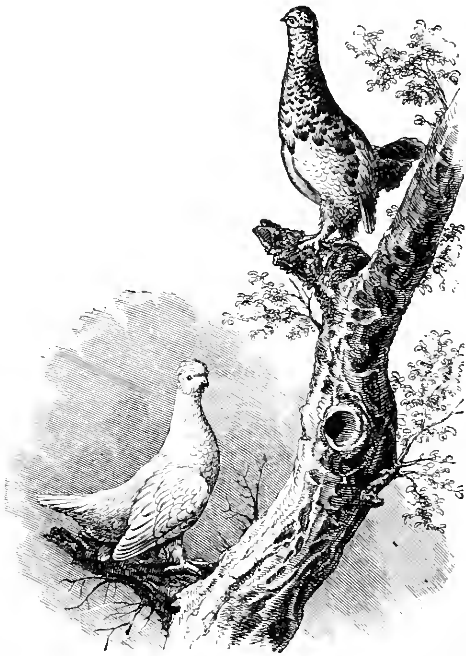

Fig. 265.—White-tailed Ptarmigan (*Lagopus leucurus*), in (upper figure) summer and (lower figure) winter plumage.

curassows (*Cracidæ*), form a sort of passage from the gallinaceous to the columbine birds. One of the most puzzling forms for the systematic ornithologist to deal with is the hoasin of Guiana (*Opisthocomus cristatus*). In this bird the keel of the breast-bone is cut away in front, the wish-bone unites with the coracoid bones, and also with the manubrium of the breast-bone, a thing of rare occurrence.

In the tinamous of Central and South America the tail-feathers are in some cases entirely wanting, and the breast-bone and skull-bones have some anomalous features. Most all gallinaceous birds have plump bodies, with short beaks and small rounded wings, not being good fliers. In some of their cranial characters they are so peculiar that Huxley makes them one of his primary divisions of *Carinatæ*.

Order 7. Columbæ (Doves, etc.).—We now come to birds

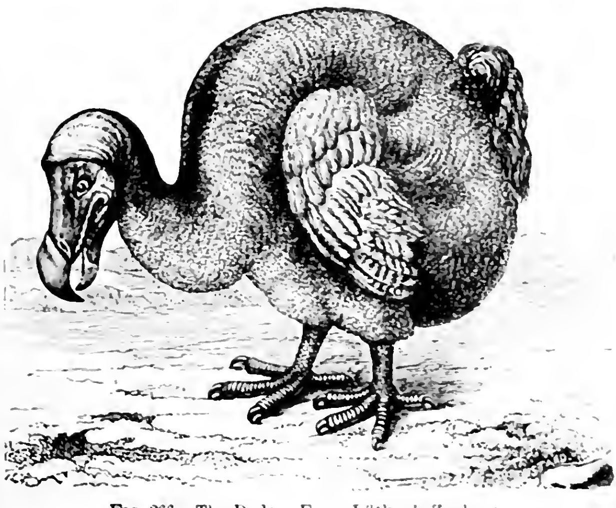

FIG. 266.—The Dodo. From Lütken's Zoology.

of a higher type, in which the knee and part of the thigh are free from the body, the leg being usually feathered down to the tibio-tarsal joint; the toes are usually on the same level, being fitted for grasping or perching.

The doves are rapid fliers, but a notable exception is seen in their extinct ally the Dodo (*Didus ineptus*, Fig. 266) of Mauritius, which became extinct on the island of Mauritius in the seventeenth century, while the solitaire, *Didus* (*Pe-*

zophaps) *solitarius,* inhabited the island of Rodriguez, having been exterminated about the same date (1681). These were clumsy, defenceless birds, incapable of flight, and were destroyed by the domestic animals which accompanied the Portuguese voyagers to the Mascarene Islands.

The wild pigeon (*Ectopistes migratorius*) assembles in large flocks, chiefly in the Central States, but though formerly excessively abundant it is now nearly exterminated, and is seen only in scattered small numbers.

Order 8. *Raptores* (Raptorial birds).—The birds of prey (*Raptores*), comprising the vultures, buzzards, falcons,

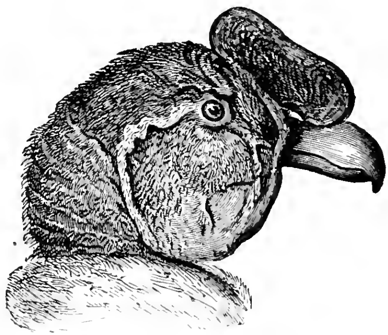

FIG. 267.—Head of Condor. From Lütken's Zoology.

hawks, eagles, and nocturnal owls, have a hooked and *cered* beak, *i.e.,* with a waxy, dense membrane situated at the base of the upper mandible. The claws are large and sharp. The raptorial birds live either on birds and mammals, or fish, reptiles, batrachians, and insects. Of the vultures, the most notable for size is the condor of the Andes (*Sarcorhampus gryphus,* Fig. 267), which has great powers of flight, its wings expanding nearly three metres (nine feet).

The carrion crow and turkey buzzard (*Cathartes atratus* and *C. aura*) are useful as scavengers, especially the former, which is partly domesticated in southern cities and towns; they nest on the ground or in stumps, and are more or less social. The bald-headed eagle (*Haliaëtus leucocephalus*) is dark-brown when young, and before shedding its youthful plumage is larger than the white-headed adult. It nests on inaccessible rocky points; is the sworn enemy of the fish-hawk, and, like it, fond of fish, often wresting its living food from the talons of the hawk. This species is the emblem of our country. The osprey or fish-hawk (*Pandion haliaëtus*) is two-thirds of a metre long, nests in tall trees,

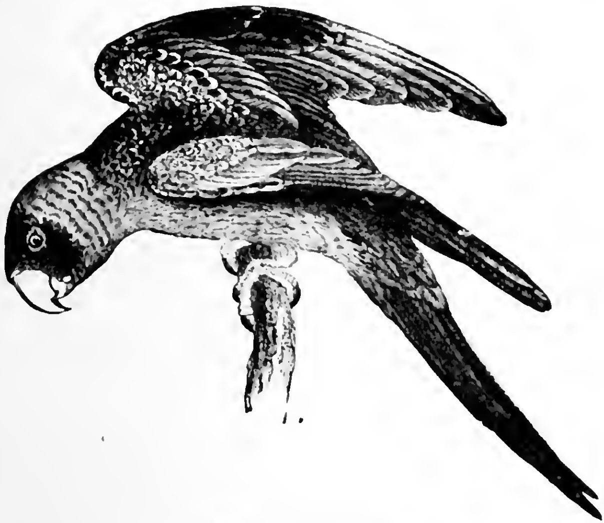

FIG. 268.—Carolina Parroquet.

and is migratory. Among the hawks, the most notable are the falcons or hunting hawks, used during the Middle Ages in hunting the hare, etc.; in nature they chase their prey and kill it immediately, devouring it, and rejecting the bones and hair of the partly digested food in a ball from the mouth.

The owl is a bird of the night; its flight is noiseless, owing to its soft plumage, the feathers having no after-shaft. It has large eyes and a hooked bill, giving the bird of Minerva an air of consummate wisdom. Owls capture living mice and other small nocturnal animals, ejecting from the mouth a ball of the indigestible portions of their meal. The little burrowing owl of the western plains (*Spheotyto cunicularia, var. hypogæa*) consorts with the prairie-dogs and rattlesnakes, nesting in the holes when deserted. Their rusty, dull hues assimilate them with the color of the soil they inhabit. Our largest owl is the great gray owl (*Syrnium cinereum*); it is nearly $\frac{3}{4}$ metre ($2\frac{1}{2}$ feet) in length, and is an inhabitant of Arctic America. A visitor in winter from the Arctic regions is the snowy owl (*Nyctea nivea*), which is nearly $\frac{2}{3}$ m., or two feet long. The great horned owl (*Bubo Virginianus*) is about the same size as the snowy owl, but has two conspicuous ear-tufts, adding to its height and its general impressiveness as a bird of more than ordinary sagacity.

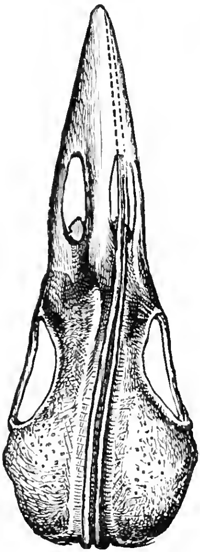

FIG. 269.—Skull of *Gecinus viridis* L., showing the asymmetrical position of the horns (*cornua linguæ*) and their extension through the right nasal opening to the end of the cavity covered by the intermaxillary.

Order 9. *Psittaci* (Parrots).—Of more intelligence and gifted with the power of speech are the parrots. The tongue is large, soft, and remarkably mobile, as the muscles at the base are more distinctly developed than in other birds, and the lower larynx is complicated with three pairs of muscles; hence these birds are wonderful mimickers of the human voice, imitating the laughter or crying of babies, and repeating brief sentences, while some sing. In proportion to their capacity for talking, parrots command a very high market price. Their toes are in pairs, the bill is cered and very stout, adapted for cracking hard nuts. The wish-bone is sometimes rudimentary, and the sternum entire, not notched. Parrots are monogamous, like the hawks, and nest in rocks or hollow trees. Our only parrot is the Carolina parroquet (*Conurus Carolinensis*, Fig. 268), which is confined to Florida. It formerly extended to the Great Lakes and to New York, but is nearly exterminated. About three hundred and fifty species are scattered through tropical countries, Australia and South America being especially favored by these gorgeous birds. The ground parrot of New Zealand does not fly, all the others being good fliers.

Order 10. *Picariæ* (Woodpeckers, etc.).—This is a somewhat miscellaneous group of birds, comprising the woodpeckers, the cuckoos, and allies, with the swifts and humming-birds, which connect the preceding groups with the Passerine or singing birds. From the latter the *Picariæ* commonly differ in the form of the sternum, in the less developed vocal apparatus, there being no more than three pairs of separate muscles, so that the birds are not musical; as well as in the nature of the toes and wing- and tail-feathers.

The woodpeckers usually have pointed, stiff tail-feathers, and the bill is straight and strong. The tongue is long, flat, horny, and barbed at the end, and can be usually darted out with great force, so that the bird can make holes in the bark of trees and draw out with its barbed tongue the larvæ of insects boring under the bark; in this way these birds render us signal service. The tongue, as in all vertebrates, is supported by the hyoid apparatus, especially by two cartilaginous appendages to the hyoid bone, called "the horns." These in the woodpeckers, when fully developed, are curved into wide arches, each horn making a loop down the neck, and thence bending upward, sliding around the skull, and even down on the forehead. Through a peculiar muscular arrangement of the sheaths in which the horns slide, they can be retracted down on the occiput, and work as springs on the base of the tongue, forcing it out with great velocity. Lindahl has noticed in some European woodpeckers an unsymmetric arrangement of the horns as indicated in Fig. 269.

The second group, the *Cuculi*, comprise the horn-bills of Malaysia, the kingfishers, the toucans of South America, known by their enormous vaulted bill, and the cuckoos, with their near relations, the African guide-birds. The female horn-bill makes a nest in a hollow tree, and the male has the extraordinary habit, while the female is sitting on her egg, of plastering up the opening with mud, so that she can only stick the end of her great bill out of the small hole. The male feeds her during the whole time of incu-

FIG. 270.—Nighthawk.

FIG. 271.—Kingbird.

bation and until the young bird is fledged. These are succeeded by the *Cypseli*, embracing the humming-birds, goatsuckers, swifts, nighthawk (*Chordeiles Virginianus*, Fig. 263), and whippoorwill, which have long pointed wings, great powers of flight, small weak feet, and, in the humming-birds, long slender bills. The latter are peculiar to America, being chiefly confined to South and Central America, only one species (*Trochilus colubris*) extending into the Eastern United States, though a dozen or more species occur in the Western United States, and very many in Mexico.

Order 11. *Passeres* (Perching birds).—The highest group of birds, those which sing, are the Passerine birds or perchers. In these birds the feet are adapted for grasping, one toe projecting backward, while the bill is horny,

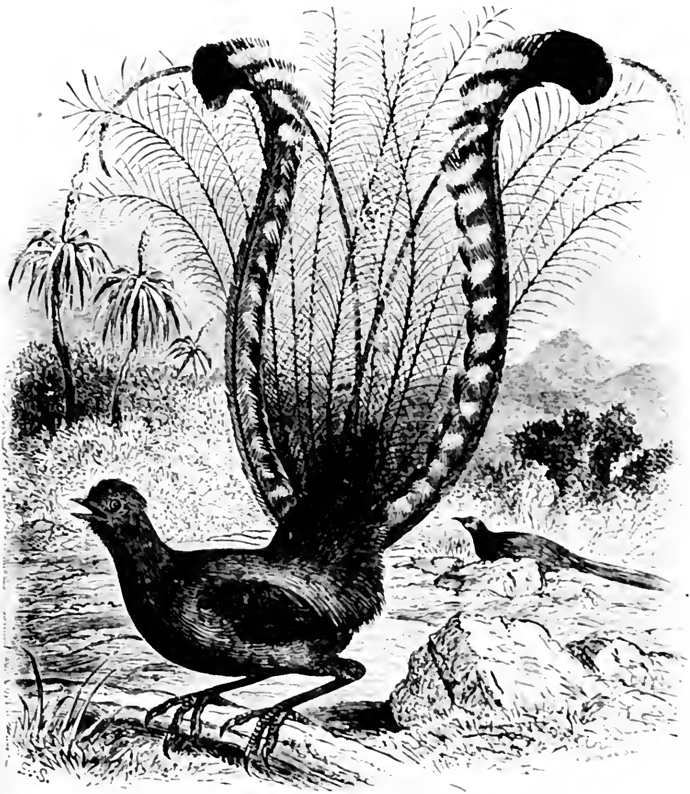

FIG. 272.—The Lyre-bird of Australia (*Menura superba*).

usually sharp—conical, according to Coues. Various as are the shape of the wings, they agree in having the great row of coverts not longer than half the secondaries; the primaries either nine or ten in number, and the secondaries more than six. The tail, extremely variable in shape, has twelve rectrices (with certain anomalous exceptions). There is but one common carotid artery, and the sternum is very uniform in shape. Their high physical irritability is co-ordinate with the rapidity of their respiration and

Fig. 273.—Magpie.

circulation; they consume the most oxygen and live the fastest of all birds (Coues).

There are two groups of Passerine birds, differing in the structure of the lower larynx; in the first (*Clamatores*) the vocal organs are more or less rudimentary, the species not being singers, while in the second and higher division (*Oscines*) the lower larynx is so developed that most of the species excel as singers. In the singing birds the vocal apparatus (*syrinx*), or lower larynx, is situated next to the lungs at the end of the windpipe, with a muscular apparatus formed of five or six pairs of muscles, whose action varies the tension of the vocal cords and narrows or widens the glottides, which are elastic folds of the mucous mem-

FIG. 274.—The Red Bird of Paradise. From Lütken's Zoology.

brane. A fold of the tympanal membrane of the syrinx, called the *membrana semilunaris*, projects inward.

Representatives of the *Clamatores* are the Arcadian fly-catcher, the wood pewee, the pewee or phœbe-bird, and the kingbird (Fig. 271). The last, sometimes called the bee-martin, destroys a thousand noxious insects for every bee it eats. The lyre-bird (Fig. 272) is also a member of this group. This bird, with tail feathers so strikingly developed as to resemble in outline a lyre, is so peculiar among higher Passerine birds that it has been proposed to separate it, with certain probable allies, from all the rest.

The Oscines are represented by a host of species. These birds stand at the head of their class; and as they are mostly of small size, it may be said of them that they excel in quality, not quantity, being highly wrought, exquisite winged gems; most of them sing. Among the most notable are the jays, including the magpie of the Rocky Mountains (Fig. 273), the crow, and blackbird, so useful a bird,

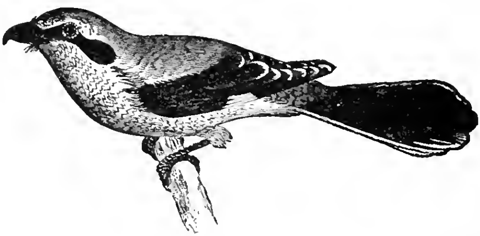

FIG. 275.—Butcher-bird.

notwithstanding its mischievous propensities. The birds of paradise (Fig. 274, *Paradisea rubra*) are allied in their size and habits to crows, starlings, and blackbirds, and are noted for their beautiful feathers forming plumes, trains, fans, or shields, the middle feathers of the tail often being lengthened into wires, twisted into fantastic shapes, or adorned with the most brilliant metallic tints. They inhabit New Guinea and the neighboring islands. Succeeding the crows, etc., are the oriole, whose hanging nest, brilliant colors, and lively song render it one of our most interesting birds; and the reed-bird of the South, or bobolink, as it is called in the North, which wakes up the meadows with his lively notes. The finches with their conical beaks are succeeded, in the ascending series, by the

English sparrow, a bird which perhaps has been useful in Eastern cities in destroying canker worms, but is now a general nuisance both in the city and the country. Our song-sparrow (*Melospiza fasciata*) is widely distributed, and everywhere commends itself by its pleasant notes. Quite opposed in its habits is the butcher-bird or shrike (Fig. 275), a quarrelsome, rapacious bird, which feeds on insects or small mammals, often impaling them on thorns or sharp twigs, and leaving them there. The group of vireos or greenlets (Fig. 276) are peculiar to America; their bills are hooked, with a notch at base; they are warblers. The

Fig. 276.—Warbling Vireo.

Fig. 277.—Carolina Waxwing.

wax-wing (*Ampelis cedrorum*, Fig. 277) is the type of an allied family. The swallows and martins are interesting from the change made in the nesting habits of the more common species which rear their young in artificial nests or in barns, or under the eaves of buildings.

Another group characteristic of North America is the warblers, *Dendrœca* (*D. virens*, Fig. 278) being the representative genus. On the other hand, the larks are an Old World assemblage of birds, but few species occurring in this country, while the wrens (Fig. 279) are mostly restricted to America.

The smallest bird in the United States, except the humming-bird, is the gold-crested kinglet (*Regulus satrapa*), which is less than 9 cm. ($3\frac{3}{4}$ inches) in length. Lastly

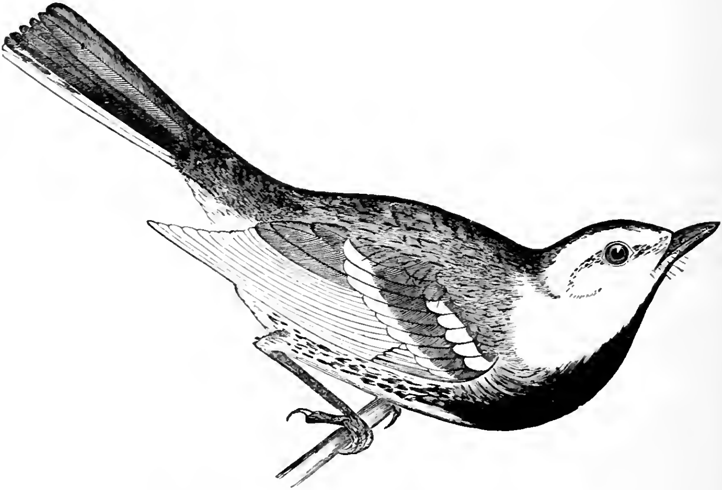

FIG. 278.—Black-throated Green Warbler.

FIG. 279.—Winter Wren.

come the bluebird, the melodious thrushes, and the mocking-bird, while at the head of the entire class of birds in this country stands the robin (*Turdus migratorius*).

The robin is our most common bird; it begins to nest before the leaves begin to appear; a pair will build the exterior of their nest in two or three days, but the lining is not finished until after the first egg is laid: hence it is about a week before the nest is completed and the first egg laid.

CLASS VIII.—MAMMALIA (*Rat, Dog, Monkey, Man*).

General Characters of Mammals.—In this the highest class of vertebrates hair takes the place of feathers, and the young are nourished with milk. Mammals walk on all fours, man being the only truly upright mammal, walking firmly on his hinder limbs, and using his fore limbs as arms for grasping and performing all those actions which minister to his intellectual wants.

FIG. 280.—Arm bones of the thumbless Monkey (*Ateles*).

As we ascend in the mammalian series, the limbs, particularly the fore-limbs, are variously modified. The limbs of whales are paddle-like, though the bones of the limbs are identical with those of other mammals. The feet of the seal are webbed, forming flippers; it cannot support itself on its limbs, but the fore-feet have considerable freedom of motion. In the dog the fore-limbs have but little motion of the radius on the ulna, but the cats have more of this rotary motion, enabling them to grasp with the fore-foot. This rotary motion of the fore-arm, the fore-foot becoming a hand, is seen in the thumbless monkeys (Fig. 280), and in those provided with a thumb, in the gorilla, and especially in man. The extreme of specialization of all four limbs is seen in the horse, which has but one digit or toe and walks on its single toe-nail.

Mammals have larger brains, and a more roomy brain-cavity in the skull than any of the lower animals, while the teeth are of four kinds, *i.e.*, molars, premolars, canines, and incisors.

Many mammals, especially those that chew the cud, as the leer, ox, rhinoceros, etc., are armed with horns. There are two kinds of horns—those with a bony core surrounded with a horny case of skin as in the deer; while in others, as the antelopes, sheep, goats, and oxen, the horns are hollow.

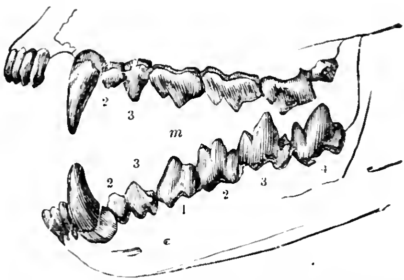

FIG. 281.—Teeth of a Mammal. The incisors are placed in front of the large conical canine teeth; 2, 3, premolars; *m*, 1–4, four molar teeth.

In most horned mammals the horns are not shed; in the deer they drop off every year; in the prong-horned antelope the horns are also shed yearly.

It is a rule that the males of such animals as are provided with tusks or horns always fight for the possession of the female. It is so with bulls, deer, elephants, boars, and rams; at the same time these are organs of defence by which the males protect their family, flock, or herd. On the other hand, in the female rhinoceros, some antelopes, the reindeer, as opposed to the other deer, some sheep and goats, etc., the horns are nearly as well developed as in the opposite sex. The modes of attack are various: the ram charges and butts with the base of his horns, the domestic bull gores and tosses any troublesome enemy, while the Italian buffalo "is said never to use his horns; he gives a tremendous blow with his convex forehead, and then tramples on his fallen enemy with his knees." Darwin also says that male quadrupeds with tusks use them in a variety of ways: thus the boar "strikes laterally and upward, the musk-deer with serious effect downward," while the walrus can strike either upward, downward, or sideways with equal dexterity.

The males are usually larger when there is any difference in size; this is seen in the eared seals, in the ox, Indian buffalo, and the American bison, as well as the lion. The mane of the latter adds to its appearance of greater weight and bulk, and Darwin says that the lion's mane "forms a good defence against the one danger to which he is liable—namely, the attacks of rival lions." As regards distinctions in color, male ruminants are most liable to exhibit them. In the Derbyan eland the body is redder, the neck much blacker, and the white band separating these colors broader than in the females. In the Cape eland the male is slightly darker than the female. In the Indian black-buck the male is very dark, almost black, while the female is fawn-colored: male antelopes are blacker than the female. The Banteng bull is almost black, while the cow is of a bright dun. Among the lemurs the male of *Lemur macaco* s coal-black, while the female is reddish yellow. The sexes of monkeys differ much in coloration. Certain male seals, bats, rats, and squirrels have brighter colors than in the opposite sex. On the other hand, the female Rhesus monkey is adorned with a brilliant red naked ring around the tail; this is wanting in the male, which, however, is larger, with larger canines, more bushy whiskers and eyebrows; and Darwin states that in monkeys the males usually differ from the females in "the development of the beard, whiskers, and mane."

The vocal organs of mammals are, in general, constructed on the same type. The larynx is formed by a modification of the uppermost ring of the windpipe, called the *cricoid* cartilage, to the anterior and dorsal edges of which two *arytenoid* cartilages are attached, while a V-shaped *thyroid* cartilage, open behind, is attached to its side. The *vocal cords,* which are modified folds of the mucous membrane lining the windpipe, are stretched between the arytenoid and thyroid cartilages, the slit between them being called the *glottis,* which is covered by the *epiglottis.* Thus, in mammals the organs of voice are situated almost solely at the upper end of the trachea or windpipe. In the voiceless whales the vocal cords are not developed. The male gorilla, which has an exceedingly loud voice, as well as the adult male orang and the gibbon, is provided with a laryngeal sac. In the howling monkey of Brazil, the hyoid apparatus and larynx are remarkably modified, the body of the former being changed into a large bony drum or air-sac communicating with the larynx. The vocal organs are a third larger in the males than in the females. "The males begin the dreadful concert, in which the females, with their less powerful voices, sometimes join, and which is often continued during many hours" (Darwin). They apparently howl, as birds sing, for the simple pleasure of the thing. Apparently, the most musical mammal, man excepted, is a gibbon, which can sing "a complete and correct octave of musical notes."

Animals are mutually attracted or are individually protected from the attacks of other species by odors. The scent-bags or odoriferous glands secreting a fluid differing in consistency in different animals, are situated near the base of the tail, as in the skunk, pole-cat, musk-deer, civet-cat and allies, or they may be developed in the side of the face, as in the male elephant, as well as sheep and goats. The odor is either of musk or some form of it. The shrew-mice, by reason of their odoriferous glands, are disliked and consequently not hunted by birds. Universal deference is paid to the skunk; few dogs, and only those which are inexperienced or peculiarly gifted, attacking them.

Some mammals have a summer and a winter dress. The hare, at the beginning of winter, doffs its summer coat for a suit of white. The hibernation, or winter-sleep, is a remarkable feature in the life of quadrupeds living in the north temperate zone, such as the bear, dormouse, and bats. During this period the temperature of their body falls, respiration and circulation are lowered in the one case, or nearly ceases in the other, and life is sustained by their living on the fat which accumulates on the under side of the neck in the so-called hibernation-glands.

There are about 3500 species of mammals described, of which 2100 are living; of these 310 inhabit America north of Mexico. Mammals live all over the earth's surface, but mostly in the tropical regions. The geographical range of certain species is very great—for example, the cougar, panther, or puma ranges from British to South America (Chili).

SUB-CLASSES OF MAMMALS.

1. With long toothless jaws like a duck's bill, laying eggs in a mammary pouch. *Ornithodelphia:* Duckbill.
2. With a pouch for holding the young. *Marsupialia:* Opossum.
3. With a placenta; brain in most cases with convolutions.... .... *Monodelphia:* Rat, Dog, etc

SUB-CLASS I.—ORNITHODELPHIA.

General Characters of Monotremes.—The duckbill and spiny ant-eater (Fig. 284, *Echidna hystrix*) are the only representatives of the sub-class, of which there is but a single order, called *Monotremes.* Besides peculiarities in the breast-bone and other parts, one of the most obvious is the long, toothless jaws (there are eight horny teeth in the duckbill), which are long and narrow in the *Echidna*, or broad and flat in the duckbill (*Ornithorhynchus paradoxus*), where it is covered by a leathery integument; the external ear is wanting. Both animals lay true eggs.

In the aquatic duckbill (Fig. 282) the feet are webbed, with claws of moderate size. It is covered with a soft fur, and is about half a metre (17–22 inches) long. Its habits are like those of a muskrat, frequenting rivers and pools in

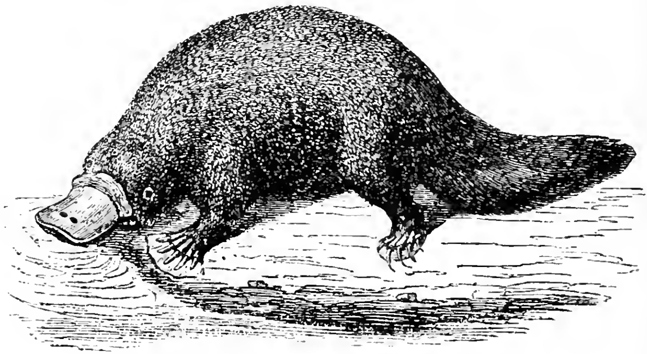

FIG. 282.—Duckbill. Australia. From Lütken.

Australia and Van Diemen's Land, sleeping and breeding in holes extending from under the water up above its level into the banks, and with an outlet on shore. It lives on

FIG. 283.—*a*, Young Duckbill; *b*, young Echidna; *c*, section of the ventral pouch. From Lütken.

mollusks, worms, and water-insects. Young duckbills five cm. (2 inches) long have been found in their nests.

The spiny ant-eater (Figs. 283, *b*, *c*, and 284) is represented by three species, one inhabiting Australia, another Port Moresby, New Guinea, while the third form inhabits

FIG. 281.—Spiny Ant-eater (*Echidna hystrix*), one third natural size.

the elevated portions of northern New Guinea. In these singular animals, which in some respects are a connecting link between birds and mammals, the tongue is long and slender, like that of the ant-eater, while the body is armed with quills like those of a porcupine, as well as hairs. The claws are very large and strong, adapted for tearing open ant-hills in order to devour the ants. Its eggs are 2 cm. long.

SUB-CLASS II.—MARSUPIALIA.

General Characters of Marsupials.—These are singular forms, represented by the opossum in this country, and the kangaroo, with a number of other forms, in Australia. They differ from all other mammals in having a pouch

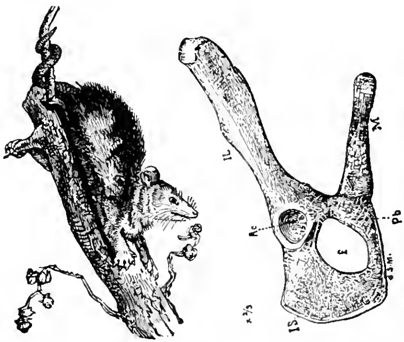

FIG. 285.—Opossum, with side view of pelvis, with the marsupial bone, *M.*

(marsupium) for the reception of the young immediately upon birth, where they are attached to the nipples at the bottom of the pouch. This large pouch (which is however absent in certain opossums and in the "Tasmanian devil") is supported by two long slender bones (Fig. 285, *M*) attached to the front edge of the pelvis, and projecting forwards.

In the opossum, the kangaroo, and probably most marsupials, the young, which are very rudimentary and small when born, remain in the pouch attached to the nipple, which fills the mouth. "To this it remains attached for a considerable period, the milk being forced down its throat by the contraction of the cremaster muscle. The danger of suffocation is avoided by the elongated and conical form of the upper extremity of the larynx, which is embraced by the soft palate, as in the *Cetacea*, and thus respiration goes on freely, while the milk passes, on each side of the laryngeal cone, into the œsophagus." (Huxley.)

Long after the young are weaned, and when they are partly grown, they run into the pouch upon the approach of danger, or enter it when tired, and, there safely ensconced, peeping out to see if the danger is past, they present a comical sight.

The lowest marsupial is the Tasmanian wolf, which is rather smaller than the true wolf. The Tasmanian devil is a vicious creature, troublesome to settlers; it is about the size of a badger.

The opossums inhabit North and South America. They have a long, nearly naked, scaly tail, and they walk, like bears, on the sole of the whole foot. The species range in size from being a little larger than a mouse to the size of a cat, and they live on birds and their eggs, reptiles and insects. The Virginian opossum (*Didelphys Virginiana*, Fig. 285) lives for the most part in trees. Lawson says that "the female doubtless breeds her young at her teats, for I have seen them stick fast thereto when they have been no bigger than a small raspberry and seemingly inanimate. She has a paunch, or false belly, wherein she carries her young after they are from those teats, till they can shift for themselves. Their food is roots, poultry, or wild fruits. They have no hair on their tails, but a sort of a scale or hard crust, as the beavers have. If a cat has nine lives, this creature surely has nineteen; for if you break every bone in their skin and mash their skull, leaving them for dead, you may come an hour after and they will be gone quite away, or perhaps you may meet them creeping away." ("Perfect Description of Virginia," 1649.)*

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* Gosse, in his "Letters from Alabama," thus describes this animal's trick of "playing 'possum." The creature had been worried

Fig. 286.—The Kangaroo (*Macropus*).

There are squirrel-like flying marsupials (*Petaurus*), marsupial rats, marsupial bears, and marsupial ant-eaters

nearly to death by dogs. "Though if left alone for a few moments, the attention of the bystanders apparently diverted from it, it would get on its legs and begin to creep slyly away; yet no sooner was an eye turned towards it, than it would crouch up, lie along motionless

(*Myrmecobius*), but the most characteristic Australian animals are the different kinds of kangaroo (*Macropus thetidis*, Fig. 286).

The largest species, *M. giganteus*, is 1.8 metres, or nearly six feet long, being as large as a sheep and sometimes weighing 140 pounds. Like other kangaroos, it goes in herds, and moves by a succession of long leaps, clearing obstacles seven or eight feet high.

All marsupials are stupid, low in intelligence, and, in those which eat flesh, of vicious temper. With the exception of the opossums, all are confined to Australia, New Zealand, and New Guinea.

SUB-CLASS III. MONODELPHIA.

General Characters of Placental Mammals.—The members of this group are called *placental Mammalia*, because the young at birth are of considerable size and nearly perfect in development, being nourished until born by a highly vascular mass or thick membrane (*placenta*) supplied with arteries and veins, developed originally from the *allantois*, which is a temporary embryonic membrane. The brain, as a rule, is higher than that of any of the preceding mammals.

ORDERS OF PLACENTAL MAMMALS.

1. No incisor teeth; sometimes entirely toothless.................. *Bruta:* Sloth, etc.
2. Rodents; with large incisor teeth..*Glires:* Rat, etc.
3. Fore limbs often adapted for burrowing; teeth sharp; feeding on insects........................*Insectivora:* Moles, etc
4. Fore limbs long, webbed, and adapted for flying...............*Chiroptera:* Bats.

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with all its limbs supple, as if just dead; nor would any kicks, cuffs, or handlings avail to produce the least token of life, not the opening of an eyelid, or the moving of a foot." The only sign of life is the tip of the prehensile tail, the end of which remains coiled up; in death this would be relaxed permanently.

5. Cetaceans; body fish-like in shape; no hind limbs.................. *Cete:* Whales, etc.
6. Body fish-like in shape; teeth like those of ruminants.............. *Sirenia:* Manatee.
7. Snout prolonged into a proboscis. *Proboscidea:* Elephants.
8. Long curved incisor teeth; feet with pads; toes hoofed................ *Hyracoidea:* Hyrax.
9. Toes hoofed..................... *Ungulata:* Horse, Ox, etc.
10. Teeth pointed for tearing flesh; claws large .... *Carnivora:* Dog, Cat.
11. Nails usually present; walking on all fours; or using fore legs as hands, or erect and walking on the hind legs .... *Primates:* Monkey, Ape, Man.

Order 1. *Bruta or Edentata.*—These creatures, represented by the sloths, ant-eaters, pangolins, and armadillos, stand next above the marsupials, as the brain is but little better developed than in the latter animals. The teeth may be absent, as in the common ant-eater, but when present they are not encased in enamel. Usually there are no incisor teeth, but those on the sides of the jaw may exist in the armadillo. The feet are adapted for grasping or digging, and end in large straight or curved claws. The body is either hairy or protected, as in the pangolins and armadillos, with large thick scales. They feed on insects and decayed animal matter, or on leaves. They are of moderate size, though certain extinct forms were colossal in stature.

Fig. 287.—Ai, or Three-toed Sloth, in its natural attitude.

The leaf-eating forms, viz., the sloths, differ from the other *Bruta* in the very long and slender limbs, the hinder pair the shorter. There are five teeth above and four below, which become sharp with use, like chisels; the stomach is said to be remarkably complex. In disposition these creatures are types of sluggishness; they live in trees, being absolutely helpless on the ground, not being capable of walking on the bottom of the foot.

Waterton says that, in climbing, the ai (*Bradypus tri*

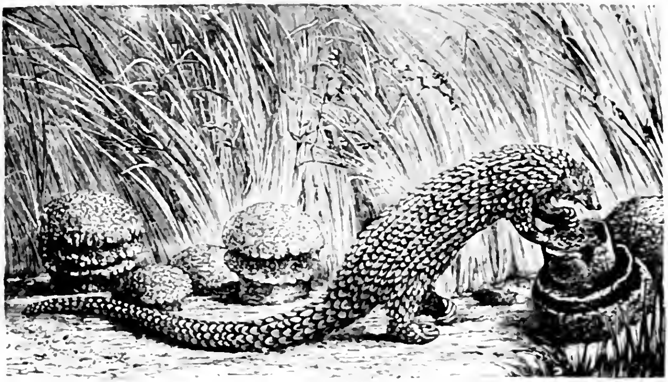

FIG. 288.—Pangolin (*Manis longicaudata*) robbing white-ant nests.

dactylus, Fig. 287) uses its legs alternately: that its hair "is thick and coarse at the extremity and gradually tapers to the root where it becomes fine as a spider's web. His

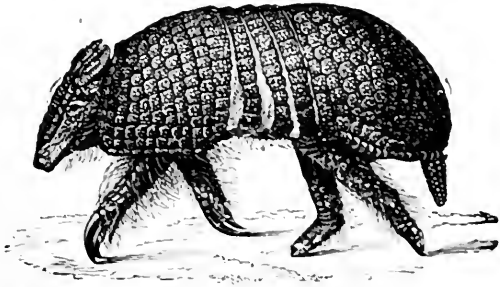

FIG. 289.—*Dasypus tricinctus.* From Lütken's Zoology.

fur has so much the hue of the moss which grows on the branches of the trees, that it is very difficult to make him out when he is at rest."

In the ant-eaters the jaws are toothless, but very long, and the tongue is of great length and very extensile; the sub-maxillary glands are very large, so that the viscid sali-

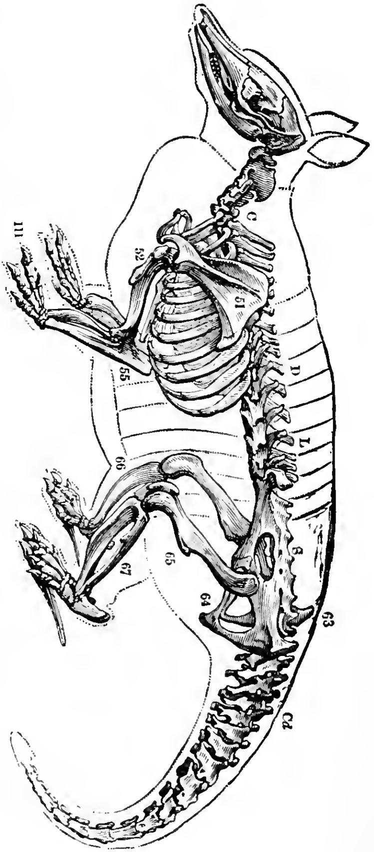

FIG. 290.—Skeleton of Peba Armadillo. *D*, dorsal region, with the outline of the girdles of epidermal scales; *L*, lumbar region; *S*, sacrum; *Cd*, caudal or tail region; 65, femur or thigh-bone (the number is opposite the point of the third trochanter); 66, tibia; 67, fibula; 51, scapula; 52, humerus; 55, ulna.

vary fluid is very abundant. They burrow into ant-holes, thrusting the tongue among the ants, which stick in multitudes to the viscid, writhing rod, and are withdrawn into the mouth. The ant-eaters (*Myrmecophaga*) inhabit South America.

The pangolins, or species of *Manis* (Fig. 288), are mail-clad ant-eaters, the body and long tail being covered with large overlapping scales. When molested they roll up the body. In walking the hind feet rest on the soles, while the fore feet are supported by the upper side of the long bent claws.

The long-tailed pangolin of the West Coast of Africa (Fig 288) tears open with its long claws the nests of the white ants. It is nearly $\frac{2}{3}$ metre (28–30 inches) in length.

The armadillos are small mammals covered with a shell, consisting of from three to thirteen transverse rows of

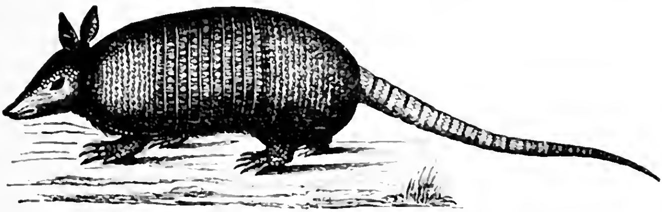

FIG. 291.—Nine-banded Armadillo. From Lütken's Zoology.

movable scales; by rolling into a ball, these singular creatures become thoroughly protected from their enemies. *Dasypus novem-cinctus* (Fig. 289) is much like the Peba armadillo (Fig. 290), and extends from South America to Texas. The three-banded armadillo (Fig. 291) can roll itself into a ball; it is an inhabitant of Brazil, Buenos Ayres, and Paraguay. According to Herbert Smith, the armadillos in Southern Brazil burrow in the grass of the plains, and the smaller species tear open the high conical nests of the white ants. "These nests are almost as hard as brick; the bones and muscles of the fore feet in the armadillos are specially modified so as to secure great strength for digging, and the large claws are used like miniature picks in boring into the tough clay." (*American Naturalist*, July, 1883).

The singular aard-vark or Orycteropus (*O. capensis*, Fig. 292) inhabits South Africa, and is timid and nocturnal in its habits, feeding on white ants.

Order 2. *Glires* (Rodentia).—The rats, squirrels, porcupine, and beaver are common examples of this extensive group. They differ from animals of other orders in the large incisor teeth and in the absence of canine teeth. The feet are adapted for walking and climbing or burrowing, the claws being long and curved. A peculiarity in the incisors is that they grow out as fast as they are worn down; this is due to the fact that the pulp is persistent; the enamel in front causes them to wear away behind so that

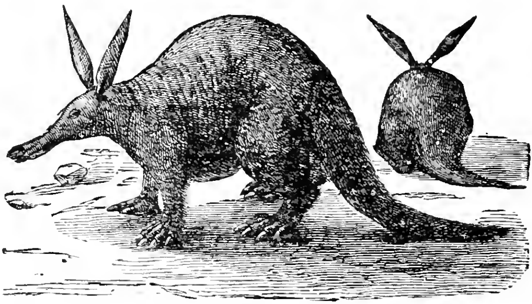

Fig. 292.—Orycteropus. From Lütken's Zoology.

they are chisel-shaped. The species are prolific, live mostly on vegetable food, and are of small size; the muskrat, beaver, and capybara being the largest members of the order. The flying squirrels (Fig. 293) take short flights by means of the expansion of the skin between the fore and hind legs, gliding from tree to tree as if supported by a parachute. They are only active at night.

The Norway lemmings (*Myodes*) are noticeable for their remarkable migrations from the elevated plateaus of Scandinavia down and into the sea; the object and origin of which are inexplicable, and are not indicative of much intelligence. While the true lemming has very small but well-formed ears, the Hudson Bay lemming (*Cuniculus torquatus*) has no external ears. It becomes pure white in winter, while the lemmings do not change. It inhabits the arctic regions of Asia and Europe as well as arctic America and Greenland. In summer it burrows under stones in dry ridges, and in the winter nests in the moss.

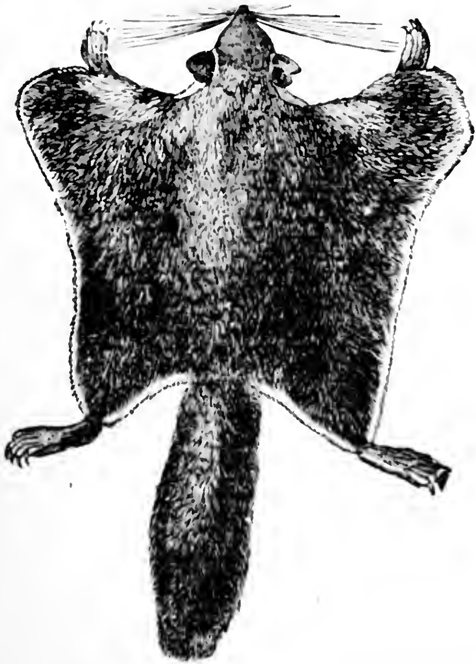

FIG. 293.—Flying Squirrel (*Sciuropterus volans*), one half natural size.

From their nest-building habits, rodents are, as a rule, not unlike birds; and Owen, for these reasons, ascribes to them a low degree of intelligence. Granting that this is the case, an exception to this rule is seen in the social beavers, which evince a high, exceptional degree of intelligence. Beavers build a dam in a running stream so as to create an artificial pond as a refuge when attacked, as well as a sub aquatic entrance to their lodges and to their burrows in the banks of the streams they inhabit. Beaver dams are built at first by a single pair or family, and are added to from year to year, and afterwards maintained for centuries by constant repairs. They are built of sticks and mud, usually curve up stream, with a sloping water-face. Beavers lay up stores of wood for winter use in the autumn; they can gnaw through trees eighteen inches in diameter; they work mostly at night. They often construct artificial canals for the transportation of the sticks of wood to their lodges. This, in the opinion of Mr. Morgan, "is the highest act of intelligence performed by beavers." When ponds do not reach hard-wood trees or ground in which

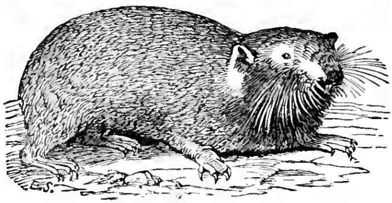

FIG. 294.—Sewellel or Showt'l. Much reduced.

they can burrow for safety, they will build canals with dams, and so excavate them that they will hold the surface drainage. Morgan describes one canal about 161 metres (523 feet) long which "served to bring the occupants of the pond into easy connection, by water, with the trees that supplied them with food, as well as to relieve them from the tedious, and perhaps impossible, task of moving their cuttings five hundred feet over uneven ground, unassisted by any descent." Beavers, in swimming, use their tail as a scull, and the hind feet being webbed, its propelling power while swimming is very great. They carry small stones and earth with their paws, holding them under the throat, and walking on their hind feet. They use the tail in moving stones, working it under so as to "give it a throw forward." Beavers are very social, working together and storing up wood in common. "A beaver family consists of a male and female, and their offspring of the first and second years, or more properly, under two years old. The females bring forth their young from two

FIG. 295.—Alpine Hare of the Rocky Mountains.

to five at a time, in the month of May, and nurse them for a few weeks, after which the latter take to bank." They attain their full growth at two years and six months, and live from twelve to fifteen years.*

Allied to the beaver, but forming the type of a distinct

* The American Beaver and his Works. By Lewis H. Morgan. 1868.

family, is the singular sewellel or showt'l (*Haplodon rufus*, Fig. 294) of the mountains of western Oregon and Washington Territory. It is nearly as large as a musk-rat, is nocturnal in its habits and therefore rarely seen, and burrows in the earth, feeding on roots.

The lowest in intelligence are, perhaps, the hares, represented by the common varying hare (*Lepus Americanus*), of which an interesting variety (*L. Bairdii*, Fig. 295) lives on the Alpine summits of the Rocky Mountains. The hares are mainly nocturnal in their habits, living concealed by day in shaded places, under fallen trees or in burrows in thickets and swamps as well as forests. Our commonest species is the white hare (*Lepus Americanus*), which turns white in December, changing to its summer dress in April. It eats grass and herbage in summer, in winter it gnaws the bark of the willow. The long-eared kinds live in the desert regions of the western plains, those with longest ears in the driest tracts. The gray rabbit or "cotton tail" (*Lepus sylvaticus*) does not change its fur in winter. In the east, according to Mr. Lockwood (*American Naturalist*, 1882), it makes a rude nest by scratching a hole sloping slightly downwards into the ground about eighteen inches. "It has a bed made of dry leaves and grass, and on top some fur or hair, which the mother has torn from her own breast. The litter numbers from four to six." There are three or four litters a season. The jackass rabbit (*Lepus callotis*) is so called from its large size and enormous ears; when running among prickly pears and sage brush it looks absurdly like a diminutive jackass. The name rabbit is only applicable to *Lepus cuniculus*, the domestic burrowing rabbit of Europe, which is gregarious and varies so wonderfully under domestication. All the hares are solitary and make nests or forms of grass on the surface; while rabbits are born blind and naked, hares are said to be born with the eyes open and hairy. The water-hare (*L. aquaticus*) lives near the water and swims and dives when pursued. In Australia the rabbits introduced there have spread so as to threaten the sheep-raising industry, as they crop the herbage, leaving none for the sheep. One colony has alone lost, in 1882, 2,000,000 sheep by them. Allied to the hares is the social pika or little chief hare (*Lagomys princeps*), which abounds among loose rocks from a little below timber-line to the snow-line in the Rocky Mountains. It sits erect like a marmot, and makes squeaking, faint bleating cries,* which appear to come from a greater distance than is really the case. It resembles in shape and color the Guinea-pig, and is only seven or eight inches long, being of the size of a rat. The largest of all existing rodents is the capybara of South America, which looks like a pig. This is succeeded by the slow, ugly porcupine (Fig. 315), which either lives in trees or burrows in the earth; it eats the bark and leaves of pine, larch, spruce and other trees, and the buds of the willow. The quills fall out at the slightest touch, and, lodged in the skin of a dog or wolf, are said in some cases to make their way into the body until they cause death. The porcupine makes its retreat among the roots of an old tree, where it sleeps much of the time. When disturbed it makes a whining or mewing noise. It pairs in British America at the end of September, and brings forth two young ones in April or May. The more intelligent, active forms are the beaver, musk-rat, the European blind rat (*Spalax*, Fig. 296) the rats and mice, squirrels, and lastly the marmots. The domestic mouse and the two rats, the brown or Norway rat (*Mus decumanus*), the black rat (*Mus rattus*), and the common house mouse (*Mus musculus*), are cosmopolitan animals. The musk-rat or musquash (*Fiber Zibethicus*) has the hind feet partly webbed, so that it swims and dives well. It ranges from Florida to Arctic America. Northward it has three litters in the course of the summer, and from three to seven at a litter. It feeds on the roots and tender shoots of rushes and of

* Mr. J. A. Allen says "a sharp, shrill, barking cry;" but those we have heard in Colorado seem more like a faint bleat.

the sweet flag, as well as mussels. In the autumn, before the shallow lakes and swamps freeze over, it builds its low conical house of mud, the base high enough to raise the interior above the level of the water; the entrance being under water. When the ice forms the musk-rat makes breathing holes through it, and, says Richardson, protects them from the frost by a covering of mud. In severe winters these holes fill up and many of the animals die. In the summer it makes long burrows in the banks of streams, with a dry nest at the end. Richardson says that it calls "to its mates by a peculiar shrill whistle. On the approach

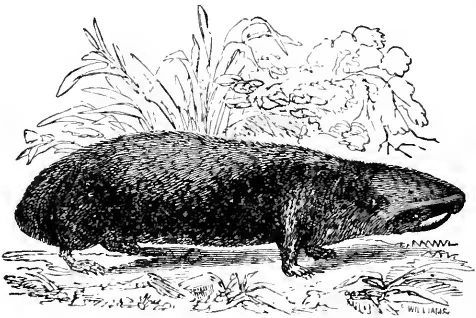

FIG. 296.—The Spalax or Blind-Rat.

of a man it utters a feeble cry, like the squeak of a rabbit when hurt." (Fauna Bor. Amer., i. 227.)

Of the squirrels the chipmunk (*Tamias Asiaticus*) inhabits Northwestern America; it is striped with five black and four white stripes on the back. It is an active and industrious little creature, with its cheek-pouches full of seeds. During the winter it lives in a burrow, with several openings made at the base of a tree. The chickaree or common red squirrel (*Sciurus Hudsonius*) may be seen in the dead of winter in pleasant weather; it burrows under trees; it feeds chiefly on nuts and seeds, and in the fur countries subsists chiefly on the seeds and young buds of the spruce. In New England it eats the seeds in pine cones, letting the scales fall to the ground under its seat on a lofty pine bough. In the winter it collects the cones of spruce and pine, and carries them to the entrance of its burrow, where it picks out the seeds beneath the snow. It also makes hoards of seeds, etc., on the approach of winter.

The gray squirrel (*Sciurus Carolinensis*) makes rude nests of leaves in trees where its young may be found in April and May. It feeds on nuts and acorns, and is active during the winter.

The wood-chuck (*Arctomys monax*) is a mischievous creature, destructive to gardens and field crops, especially red clover. It is rather social, making burrows in the sides of hills which extend to a great distance, and end in various chambers, according to the number of inhabitants. The

FIG. 297.—Jumping Mouse (*Zapus Hudsonius*).

chambers are lined with dry grass or leaves, and here they pass the winter in a torpid state, previously closing the entrance. There are six young to a litter.

The common pocket gopher (*Geomys bursarius*, see Frontispiece, left side) burrows in sandy soil and feeds on acorns, nuts, roots, and grass, which they carry to their burrows in their enormous hanging cheek-pouches, which when full have an oblong form and nearly touch the ground. It inhabits the valley of the Mississippi and its tributaries.

The jumping mouse (Fig. 297) has remarkably long hind legs and short fore legs. This creature hibernates in the winter months. According to Maynard, it enters the ground before the frosts set in, and makes a burrow from five to seven feet in depth, usually in sandy soil. At the end of this burrow it constructs a nest of dried grass, in which it lies curled up in an unconscious state. Peculiar to the Western plains is the prairie-dog (*Cynomys Ludovicianus;* see Frontispiece, on the right side), which represents the marmots of the Old World; it is semi-social, and takes in perforce as boarders the owl and rattlesnake, which devour its young.

Order 3. *Insectivora.*—In the moles the fore feet are plantigrade, with large claws, and the entire limb is short, thick, muscular, and adapted for burrowing in the soil (Fig. 298). The shrews comprise the smallest mammals. Nearly all are nocturnal, burrowing under the surface, and never seen by day; consequently, their eyes are small, and mostly hid under the fur; while the ears are small and concealed by the hair.

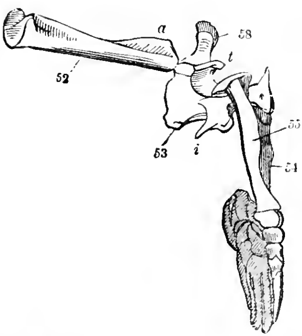

Fig. 298.—Bones of fore-leg of a Mole. 52, the cubital scapula; 53, humerus; 54, ulna; 55, radius.

The shrews are mouse-like, having feet of the normal form, and a long nose. In our common shrew (*Sorex platyrhinus*, Fig. 299), the nose is long, and the tail shorter than the head and body.

The genuine moles are the characteristic forms of the order; the most peculiar being the star-nosed mole, *Condylura cristata*, which occurs from the Atlantic to the Pacific Ocean, while the common mole (Fig. 300) is abundant in the Eastern United States.

A flying form, with a superficial resemblance to the bat, and with the same habit of sleeping head downward, holding on by its hind feet, is the *Galeopithecus* of the East Indies. This singular creature has been placed among the lemurs by some authors. *G. volans* inhabits Java, Sumatra, Borneo, and Siam.

This creature, says Wallace, has a broad membrane extending all round its body to the extremities of the toes, and to the point of the rather long tail. This enables it

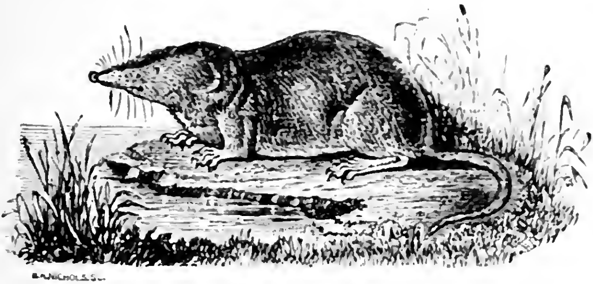

FIG. 299.—Common Shrew.

to pass obliquely through the air from one tree to another. Wallace observed one fly seventy yards, the amount of descent not being more than thirty-five or forty feet, or less

FIG. 300.—Common Mole (*Scalops aquaticus* Linn.)

than one in five. "This I think proves that the animal must have some power of guiding itself through the air, otherwise in so long a distance it would have little chance of alighting exactly upon the trunk." Its food consists chiefly of leaves.

Order 4. *Chiroptera* (Bats).—The bats form a well-circumscribed group of mammals, very distinct from any other, especially in the greatly modified fore-limbs, the radius and ulna being united, and the second to the fifth metacarpal bones and phalanges being very long and slender, supporting a thin, leathery membrane or skin, extending to the hind legs, and wholly or partly enclosing the tail; the hind toes being, however, free, as when at rest or in the vegetarians when feeding, bats hang head downwards, holding on by their claws. The sternum is slightly keeled for the attachment of the muscles of flight. The mammary glands are pectoral. In other respects, especially the dentition, the bats resemble the *Insectivora*. The form of the teeth differs from the ordinary insectivorous bats in those which live on fruit. The vegetable-eating or fruiting bats have a superficial resemblance to the flying lemurs; and because their mammæ are pectoral, have been placed next to the Primates.

Bats live in caves and in the hollow of trees by day; all hibernate in the same situations, going into winter quarters in the autumn, and reappearing in the warm twilight of spring. Though the eyes are small, and the sight, so far as we know, deficient in keenness, they show wonderful skill in avoiding objects during their rapid flight. The ears are very large, and in the vampires the nose is adorned with sensitive, leaf-like growths of complicated form. Certain bats, but not the true vampires, are known to enter houses and to suck the blood of sleeping persons, who awake to find their feet covered with blood.

The largest bats are the fruit bats or flying foxes (*Pteropus*) of the East Indies, one species of which expands one and a half metres (nearly five feet) from tip to tip of the wings. They assemble in large flocks in the Moluccas to eat fruit, by day hanging by thousands on the trees. Our commonest species is the little brown bat (*Vespertilio subulatus*); nearly as common is the red bat or *Atalapha noveboracensis*.

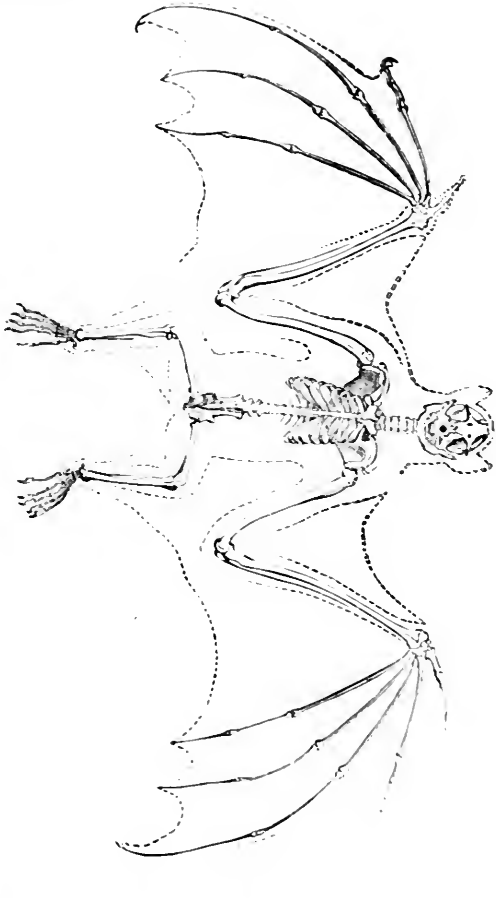

FIG. 301.—Skeleton of a fruit bat (*Pteropus*).

Order 5. *Cete* (*Cetacea*, Whales).—The foregoing orders belong to a series called *Ineducabilia*, because they are not generally so intelligent as the succeeding orders, their brain having the cerebral hemispheres small, smooth, with none or few convolutions, in front not covering the olfactory lobes, and behind leaving the cerebellum wholly or partly uncovered. We now come to the *Educabilia*, in which the brain is more highly developed, the cerebral hemispheres being furrowed or convoluted, and partly or almost wholly covering the cerebrum. We begin with two very aberrant orders, the whales and Sirenians, in which the body is fish-like, though the tail is horizontal; the pelvis and hind limbs are wanting, either wholly, or minute rudiments may be present; and they are aquatic, occasionally leaping out of the water, but usually only showing the dorsal fin or nose when at the surface to breathe.

The whales and porpoises have a large, broad brain, with numerous, complicated, and deep convolutions.

In the skull the aperture for the spinal cord is entirely posterior in situation and directed somewhat upward. The lower jaw is straight. The teeth are conical, with a single root, but are sometimes wanting. There is no neck; the cervical vertebræ are sometimes confluent, forming a single mass. The limbs form a pair of paddle-like appendages just behind and under the head, which are supported by short, flattened limb-bones, the carpals and phalanges often separated by cartilage; the second digit being composed of more than three phalanges. There are two mammæ situated near the tail. The external nostrils are either single or double, and are situated on the top of the head; they are modified to form the spiracles or "blow-holes;" certain folds of the skin prevent the water from entering the air-passages. The vapor blown from the holes does not consist of water, but of the mucus from the nostrils, and the moisture in the breath. The blow-holes vary in form in different kinds of whales. The "spout" or stream of vapor issues in a single short stream from the extreme end of the snout, and curls over in front of the head; that of the fin-back whale forms a single column of vapor about ten feet high; the right, humpback, and sulphur-bottom whales each "blow" in a double stream, which is directed backward toward the tail.

Whales are rarely over fifty feet long; the sperm-whale has been known to reach a little over twenty-three metres (76 feet) in length, but Professor Flower questions whether the sperm-whale frequently, if ever, when measured in a straight line, exceeds a length of sixty feet. The largest

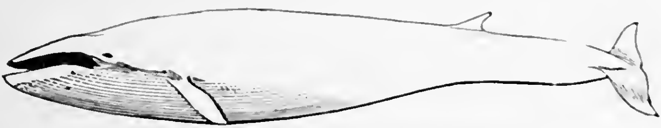

FIG. 302.—Fin-whale. From Lütken's Zoology.

of all whales, as of all existing animals, is the fin-back (Fig. 302) or rorqual (*Balænoptera boops*), which sometimes measures thirty-four metres in length. The smallest Cetacea are the porpoises.

In the whalebone whales, the teeth, present in the embryo, become reabsorbed into the gums before birth and

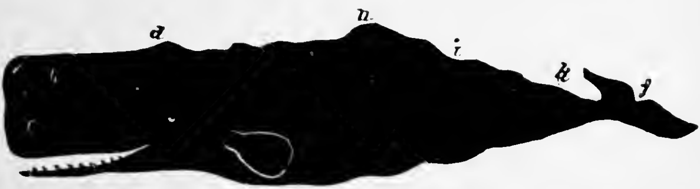

FIG. 303.—Outline of the cachelot, showing how the blubber is removed: *b*, the situation of the "case;" *c*, the junk; *d*, the bunch of the neck; *h*, the hump; *i*, the ridge; *k*, the small; *f*, the tail or flukes; between the oblique dotted lines are the spiral strips or blanket pieces.

are replaced by plates of whalebone, three hundred of which may be present on each side of the mouth. The inner edges of these plates have projecting fibres, forming a rude strainer; these whales feed on small pelagic jelly-fish, mollusks, and crustacea, by taking in a mouthful of water, and then pressing the tongue against the roof of the mouth, expelling the water through the openings between the plates, the fibres acting as a strainer. Three thousand five hundred pounds of whalebone have been obtained from a single bow-head or Greenland whale (*Balæna mysticetus*).

The cachelot or sperm-whale (*Physeter macrocephalus*, Fig. 303) has an enormous head, and is without the power of smell. In the upper jaw are cavities filled with a fatty fluid called *spermaceti*, used in the manufacture of candles, ointments, and cosmetics, such as cold cream. A large sperm-whale will yield 2500 kilograms of this substance. Another valuable substance is *ambergris*, a morbid product, the result of injury to the intestines by the beaks of cuttle-fishes, upon which animals the toothed whales largely prey. It is a kind of bezoar or gall-stone, fatty, aromatic, burning with a clear flame. It is composed of benzoic acid,

FIG. 304.—The Pigmy Whale (*Kogia Floweri*).

united with chlorine, of a balsamic substance, and ambrain. It is used in making perfumes.

But the chief use of whales is the oil extracted from the fat enveloping the body, called blubber by whalers. The most valuable of the whales is the Greenland whale, as it contains the most oil, individuals having been known to yield nearly three hundred barrels.

The whale fishery first sprang up in the twelfth century in the Bay of Biscay. In the New England colonies whales were pursued in boats from the shore. In 1854 the fishery culminated; since then it has decreased. It is principally carried on by Americans, New Bedford being now the leading port from which whalers are sent out to the Arctic regions and Behring's Straits, one hundred and ten vessels having been sent out in 1876 from this port, Closely allied to the sperm whales are the pigmy whales, represented on the Californian coast by *Kogia Floweri* (Fig. 304), which is nearly three metres (nine feet) in length, with a conical head.

The narwhale (*Monodon monoceros*) is distinguished by the long, spirally-twisted, horn-like tusk of the male, formed of the left upper incisor, which becomes nearly three metres long, the female having no visible teeth; there being two rudimentary incisors which never appear through the gum. It ranges from the coast of northern Labrador to the Arctic Seas.

To the family of dolphins and porpoises belong the white

FIG 305.—South American Manatee. From Lütken's Zoology.

whale, or *Delphinapterus leucas*, which ranges from the Gulf of St. Lawrence northward; the grampus (*Grampus griseus*); the black-fish, of which there are two species, one *Globicephalus melas*, ranging north of New York, and the other, *G. brachypterus*, extending to the southward; and the porpoises, of which the most common on our coast is *Phocæna brachycium*, the rarer being *Phocæna lineata*. On the coast of Labrador, as well as northward, occurs the thrasher or killer (*Orca gladiator*), which has large teeth and a high dorsal fin; it attacks whales, gouging out the flesh from their sides. Certain extinct whales, judging by their fossil remains, were pygmies in size, while the *Zeuglodon* of the eocene tertiary beds of Alabama was an enormous serpent-like whale, which must have measured over 70 feet in length.

Order 6. Sirenia.—**General Characters of Sirenians.**—This small group is represented by the sea-cow or manatee of Florida. The lower jaw is unlike that of whales, being

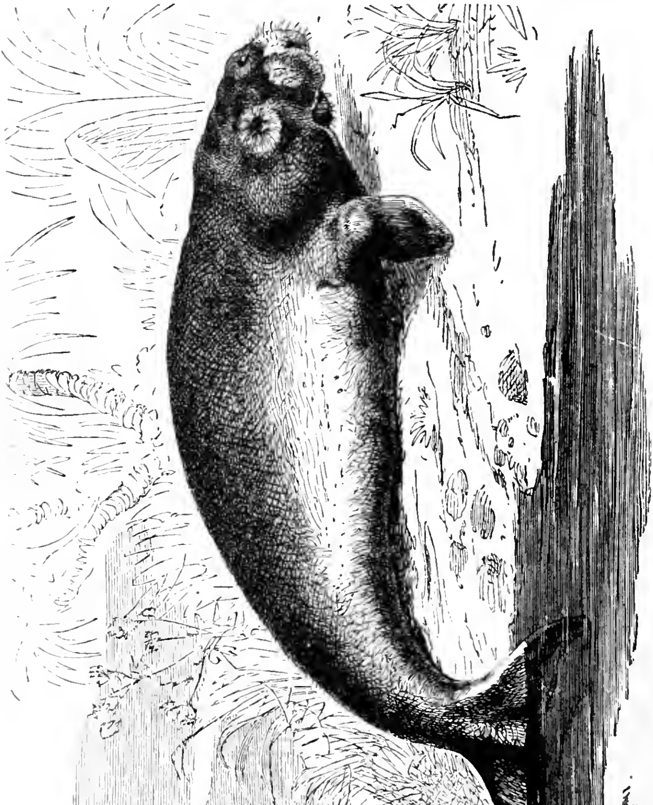

FIG. 306.—The Dugong.

much as in the cow or horse, while the teeth are well developed, both incisors and molars, the latter with flattened or ridged crowns, adapted for the trituration of vegetable food. The neck is slightly indicated; the two nostrils are situated at the upper part of the snout, and the lips are beset with stiff bristles, while the mammae are situated between the fore legs. The latter are of moderate length, with five well developed digits, but still fin-like and bent at the elbows. The brain is narrow compared with that of Cetaceans, and the heart is deeply fissured between the ventricles. The manatees of America (Fig. 305) and the dugong of Australia and India (Fig. 306) live in the mouths of large rivers, feeding on sea-weeds and aquatic plants or the grass along the shore. The Floridan manatee (*Manatus Americanus*) grows to a length of from two to nearly three metres (6–14 feet). It ranges from Florida to the Amazons, where it is called *Vacca marina;* it ascends that river as far as Pebas, Peru, and is killed and eaten, its flesh resembling beef. Steller's manatee (*Rhytina Stelleri*) was in the last century found in abundance on the shores of Behring's Island on the coast of Kamtchatka. Twenty-seven years afterwards (in 1768) it was totally exterminated by the sailors who visited that locality, and only a few imperfect skeletons now exist in the museums of St. Petersburg and Stockholm. This is the largest Sirenian known: it was over six metres (about twenty feet) in length. It differed remarkably from the other forms in having no teeth, but was provided with a very large, horny, palatine plate, and a corresponding one covering the enlarged point of union (symphysis) of the lower jaws. In the Tertiary Period a fossil Sirenian (*Halitherium*) inhabited the shores of western Europe.

In the structure of the skull, the nature of their teeth, and their herbivorous habits the Sirenians in a degree connect the Cetaceans with the Ungulates.

Order 7. Proboscidia.—Only two representatives of this group are now in existence, the Asiatic and African elephant, a number of other forms having become extinct. The group is well circumscribed, when we consider the living species, but in the early (Eocene) Tertiary Period there existed forms which indicate that the Proboscidians and Ungulates had a common origin. In the elephants the upper incisor teeth are enormously developed, forming the tusks so characteristic of these animals, while there are none in the lower jaw. There are no canine teeth, while the few molars are large and transversely ridged. In the elephants the ridges on the molar teeth are numerous, the

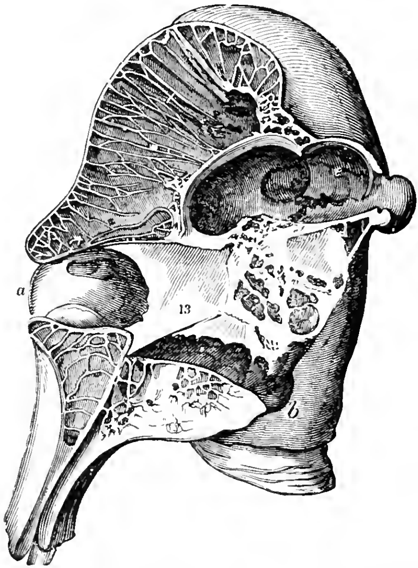

Fig. 307.—Section of an elephant's skull, showing the small size of the brain cavity as compared to the whole skull, and the numerous large air-cells. *v*, posterior nostrils; 13, cavity of the nose; *a*, front opening of the bony nostrils, to the edge of which the trunk is attached.

spaces between them being filled with cement. The young mastodon has cement on the upper surface of the tooth; the ridges afterwards become free and covered with enamel. A peculiarity in the elephant's skull is its large size, the brain cavity being very small in proportion to the bulk of the skull itself. To give lightness to what would be otherwise an insupportable weight, the cranial bones contain numerous large air-cells (Fig. 307). Another remarkable feature, from which the group takes its name, is the trunk or proboscis, a long, thick, fleshy, flexible snout, growing from the front edge of the nasal bones (Fig. 307, *a*). The trunk ends in a finger-like, highly sensitive point, below which are situated the nostrils. The brain has a large cerebrum, with numerous convolutions, but more of the

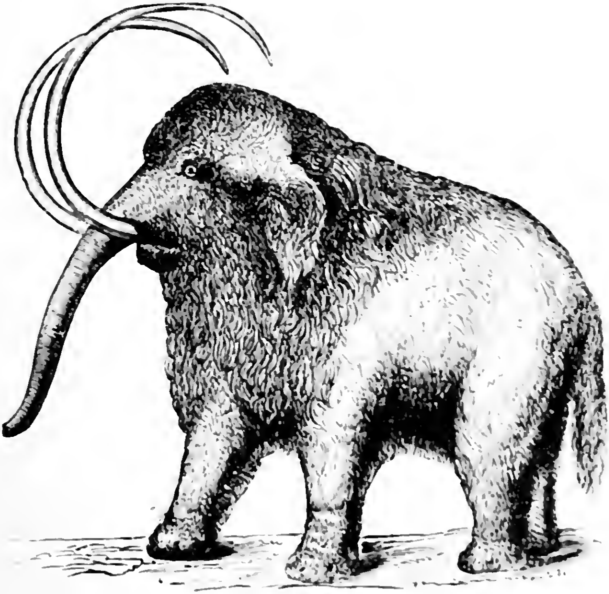

FIG. 308.—The hairy Mammoth. From Nordenskiöld.

cerebellum is exposed than in any of the succeeding orders: in this respect and in the large incisors the Proboscidians approach the *Rodentia*.

In the nature of the limbs, especially from the fact that elephants walk on their toes, a relation to the Ungulates is indicated. They are five-toed, but the digits are represented externally only by the five broad, shallow hoofs, the foot being supported by thick, broad pads. The legs are almost wholly free from the body. The placenta is zonary and deciduate. The skin is naked in the existing elephants, but the extinct mammoth was covered sparsely with long hairs. Elephants live in herds, browsing on the leaves of trees and herbs. They attain a height of from three to four metres (10–12 feet), but are rarely over nine feet in height. The Asiatic elephant has a concave forehead and small ears, while the African species has a full, rounded forehead and large ears, with four hoofs on the fore feet and three on the hind feet, the Asiatic elephant having one more hoof on each foot. The fossil mammoth (*Elephas primigenius*, Fig. 308), which was contemporaneous with early man, was not much larger than the existing species. Its tusks, however, were of great size, some being five metres long, It formerly ranged in herds over northern Europe and Asia, as well as America, bones occurring under swamps in the Northern and Middle United States. A carcass frozen in the ice, with the hair still on, was discovered near the mouth of the Lena River in Siberia. A pygmy, extinct Maltese elephant of the late Tertiary Period was only 1.7 metres in height.

The *Mastodon* was characterized by having incisors in both jaws of some of the species. It had molars with conical cusps, and was $3\frac{3}{4}$–4 metres (12–13 feet) in height. The mastodon (*Mastodon giganteum* Cuvier) was an earlier type than the elephant, and formerly inhabited the North American continent.

Order 8. *Hyracoidea.*—With some affinities to the *Rodentia*, and a decided resemblance in some particulars to the rhinoceros among the Ungulates, the members of this small order are in general characterized by having long, curved incisors; and by feet provided with pads as in Rodents and *Carnivora*, the toes being encased in hoofs (four in front and three behind). The *Hyrax*, a little gregarious animal living in holes among rocks, of which there are two or three species known, one South African, and another in the Holy Land and Arabia, thought to be the coney referred to in the Bible, is the only genus.

Order 9. *Toxodontia.*—Of this group, of which no species are now living, the types are *Toxodon* and *Nesodon*. They are placed by many authors among the odd-toed Ungulates, not far from the tapirs. Their incisors were $\frac{6}{6}$ or $\frac{4}{6}$. *Toxodon* in its skull bore some resemblance to the Sirenians, and in the teeth were in certain respects like the Edentates. The species lived in South America during the early Tertiary Period.

Order 10. *Ungulata.*—The larger proportion of mammals belong to this interesting order, which comprises nearly all those species of mammals useful to man, such as the ox, camel, pig, deer, and horse. They are, in general, characterized by walking, so to speak, on their toes, each toe being at the end encased in a horny hoof; not more than four toes being completely developed on a foot. The teeth are usually well developed, with six incisors in each jaw, but these are often, especially in the upper jaw, less in number or entirely absent, as in the sheep, deer, and ox. The collar-bone is absent. The brain still remains small compared with the bulk of the skull, and the intestinal canal is of unusual length compared with that of animals of the previous orders.

The Ungulates have been divided by Owen into two suborders, according to the odd number of toes (*Perissodactyla*) or even number (*Artiodactyla*). In the odd-toed Ungulates (Perissodactyles) there may be three toes on each foot, as in the rhinoceros, or one, as in the horse; while in the even-toed Ungulates (Artiodactyles) there may be four toes (*Hippopotamus*), or two, as in the giraffe, or two functional and two rudimental, as in the ox and deer, *i.e.*, most Ruminants. The more generalized existing form of Ungulates is the tapir; the most specialized type is the horse, with its single toe on each limb. A large number of extinct Tertiary Ungulates in the Western States and Territories, and the Tertiary basins of Paris and London, more or less allied to the tapir, especially *Coryphodon, Anoplotherium, Palæotherium*, etc., were generalized or ancestral forms, from which the modern, more specialized types have probably been evolved, and a study of these fossil Ungulates shows that there was then (*i.e.*, in Eocene times) an essential unity of organization in all Ungulates, including the Ruminants; the breaking up of the Ungulate stem into special groups, along favored lines or paths of development, having resulted in a gradual improvement and elaboration of particular parts, which rendered them more fitted for their present life, and more intelligent in meeting and overcoming the emergencies their more complex surrounding subjected them to. Thus in the Eocene Ungulates, such as *Coryphodon*, the cerebrum was small, without convolutions, indicating a slight degree of intelligence compared with the modern Ungulates, while the gradual differentiation of the horse, with its single toe and hoof, from its tapir-like ancestors, is a marked example of the intelligent, beneficent selection of favored, useful types which has gone on from the earliest geological times.

All this specialization of type involved the destruction of great numbers of forms unfitted to withstand changes in their surroundings, or not sufficiently intelligent or wary to avoid the attacks of carnivorous forms, and thus the present number of Ungulates is much exceeded by the fossil forms.

Perissodactyles. The odd-toed Ungulates, on the whole, stand lower than the even-toed forms. They all have at least twenty-two dorsal and lumbar vertebræ, and a simple stomach, with a large, sacculated cœcum. The tapirs are the more elementary, generalized forms. Fossil tapirs occur in the older Tertiary beds of the West. The snout is almost proboscis-like, and the legs are moderately long, with four toes in front, three toes behind. The tapirs inhabit the tropics of the New World and Sumatra. The American tapir ranges from east of the Andes from the Isthmus of Darien to the Straits of Magellan. It lives in deep forests and is nocturnal and shy in its habits, living on the shoots of trees, buds, wild fruits, etc. It has a tough hide, and when attacked makes a good fight with its teeth. They are succeeded by the rhinoceros, represented in this country by a number of extinct Tertiary allies, the living species being restricted to Africa and the East Indies. The skin is remarkably thick and dense, while these animals have either one or two long median horns growing from the skin of the nose. Anderssen says that almost all the three species of Asiatic rhinoceros have an exceedingly

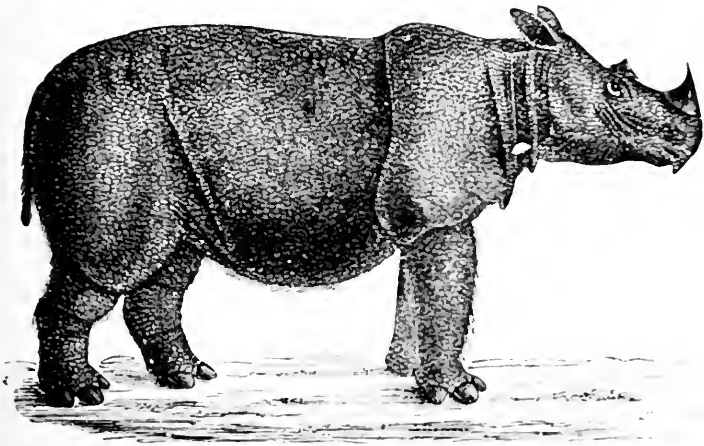

FIG. 309.—The Sumatran Rhinoceros. From Lütken's Zoology.

coarse hide, covered with large folds, not unlike a coat of mail; whilst that of the African species (*R. Africanus*) is comparatively smooth. There are four varieties of the African species, two of them whitish and two dark. The anterior horn of one of these kinds (*Rhinoceros Oswellii*), which inhabits the interior of South Africa, not unfrequently exceeds four feet in length. The body of the rhinoceros is long and thick; its belly is large, and hangs near the ground, the legs being short, round, and very strong, while its hoofs are divided into three parts, each pointing forward. The head is large, the ears long and erect, while the eyes are small and sunken. "The horns, which are composed of a mass of fine longitudinal threads, or laminæ, forming a beautifully hard and solid substance, are not affixed to the skull, but merely attached to the skin, resting, however, in some degree, on a bony protuberance above the nostrils." In size, says Anderssen, the white African rhinoceros is only exceeded by the elephant. A full-grown male (*R. simus*) measures, from the snout to the extremity of the tail (which is about two feet long), between 14 and 16 feet, with a circumference of 10 or 12. It weighs not less than 4000 to 5000 pounds. "With its huge body, misshapen head, ungainly legs and feet, and diminutive organs of vision, the rhinoceros is the very image of ugliness" (Anderssen's "Lake Ngami"). In strength also the rhinoceros is scarcely inferior to the elephant; and ungainly and heavy as it looks, is very active and swift of foot, so that, as Gordon Cumming says, "a horse with a rider can rarely manage to overtake it." Its food consists of vegetables, shoots of trees, grasses, etc. It has but one young at a birth, which is about the size of a dog, and with the merest rudiments of horns. Anderssen says that a common leaden ball will find its way through the hide with the greatest facility. A rhinoceros contemporary with early European man formerly inhabited England, France, and Germany, and extended into Siberia.

A number of fossil forms lead up to the family comprising the horse, ass, zebra, and quagga, etc., in which there is a single toe, being the third on each limb. Their dentition is—

$$I\frac{6}{6},\ C\frac{1-1}{1-1},\ P\frac{4-4}{4-4},\ M\frac{3-3}{3-3}.$$

The genealogy or series of ancestral extinct Ungulates leading from tapir-like forms to the modern horse has been worked out partly by Huxley, and especially by Marsh, who has with Leidy discovered a large series of remains in the

Tertiary beds of central and western United States, America being the original home of the horse. The earliest member of the series directly leading up to the horse was *Eohippus*, an older eocene form, about as large as a fox, which had four well-developed toes and the rudiments of a fifth on each fore-foot, and three toes behind. In later eocene beds appeared an animal (*Orohippus*) of similar size, but with only four toes in front and three behind. In newer beds, *i.e.*, lower miocene, are found the remains of *Mesohippus*, which was as large as a sheep and had three toes and the splint of another in each fore-foot, with but three toes behind. In later miocene beds another form (*Anchitherium* or *Miohippus*) had the same number of toes, but with the "splint bone of the outer or fifth digit reduced to a short remnant." The splint bones, then, represent two of the digits of several toed animals. The succeeding forms were still more horse-like. "In the Pliocene above, a three-toed horse (*Hipparion* or *Protohippus*), about as large as a donkey, was abundant, and still higher up a near ally of the modern horse, with only a single toe on each foot (*Pliohippus*) makes his appearance. A true *Equus*, as large as the existing horse, appears just above this horizon, and the series is complete." (Marsh.) Fossil horses extended over portions of North and South America, but are supposed to have become extinct before the present Indians appeared, though there are indications that the horse was living on the plains of both North and South America at the time of the discovery of the country, and that the Indians used them.

The horse (*Equus caballus*) is the most useful of all domestic animals, and next to ships a prime means of the diffusion of civilization. By artificial selection a great number of varieties, races, and strains have been produced, adapted for the performance of different kinds of work. The horse only exists in a domesticated state. Sanson states that the horse in the Orient has five, and in the west (Africa) six lumbar vertebræ; in Arabia both forms occur;

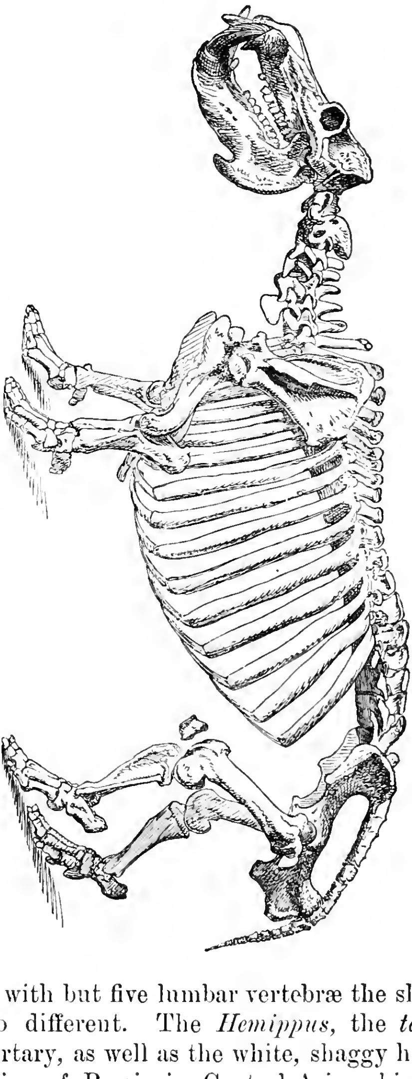

Fig. 310.—Skeleton of the Hippopotamus. From Brehm's Thierleben.

in the horse with but five lumbar vertebræ the shape of the skull is also different. The *Hemippus*, the *tarpau* and *muzir* of Tartary, as well as the white, shaggy horse of the elevated plains of Pamir in Central Asia, which is often regarded as the original stock, may be a race which has returned to a wild state, since partly wild horses occur in Syria, on the Don, and live in great herds on the llanos and pampas of South America. There are two primitive races of horses, the Oriental and Western. To the first belong three types: the Arabian, with the Berber, Andalusian, Neapolitan; and in England the blood horse; the Nizaischan type of the Deccan, India, to which belong the Persian, Turkestan, Turkish horses, and the Tartarian. The western races comprise the Frieseland, to which belong the Brabant, Holstein, Mecklenburg, and the English farm-horse, and among others the Percheron horse, of France. Ponies are dwarf horses produced in cool, mountainous areas, such as the Shetland Islands. The wild ass (*Equus onager*) ranges from the Indus to Mesopotamia. *Equus hemionus* the Dschiggetai or Kiang, goes in herds in central Asia and Mongolia. Recently, Prevalsky, a Russian explorer, has discovered a new species of horse in the elevated portions of Central Asia, which has been named *Equus Prevalskii*. The hinny and mule are infertile hybrids of the horse and ass (*Equus asinus*).

Artiodactyles.—The even-toed Ungulates comprise the peccary, pig, hippopotamus, and the Ruminants, which are represented by the deer, sheep, ox, and camel. The pig and peccary are the descendants of a number of extinct earlier forms which flourished in the Tertiary Period; the pig, as Marsh observes, having held its own with characteristic pertinacity. The peccary (*Dicotyles*) is a small creature, closely resembling a long-legged pig. It lives in swampy tracts from Texas to Central and South America. It goes in herds, and is a fearless animal. The *Hippopotamus* (Fig. 310) has a large head, with large canines, a clumsy body, and short legs. *Hippopotamus amphibius* ranges from the Upper Nile to the Cape of Good Hope, and westward to Senegambia. It is nearly 3½ metres

FIG. 311.—Crown of deer's tooth, showing the enamel crescents.

(11–12 feet) in length, the circumference of the body being nearly the same. It is seldom over four and a half feet in height. The hippotamus has been likened to a "form intermediate between an overgrown hog and a high-fed bull without horns and with cropped ears." Its incisor-teeth attain at times two feet in length. The eyes, nostrils, and ears are all placed nearly on the same plane, which allows the use of three senses and of respiration, a very small portion of the animal being exposed when it rises to the surface of the water. The legs are very short, so that in some cases the belly almost touches the ground.

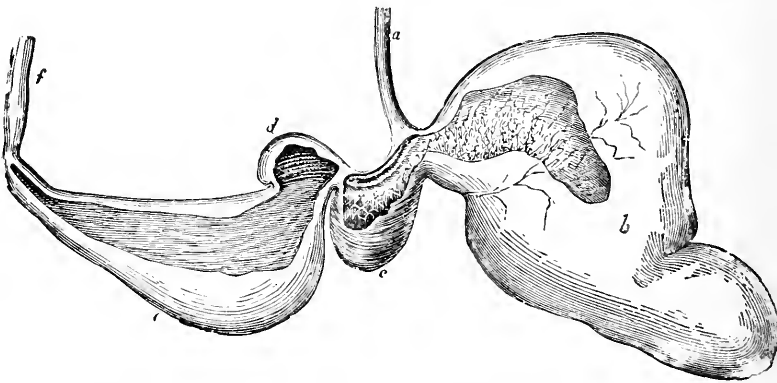

FIG. 312.—Stomach of a ruminant, showing the four compartments: *a*, œsophagus; *b*, paunch; *c*, honeycomb or reticulum; *d*, liber psalterium or manyplies; *e*, true digestive stomach; *f*, beginning of the intestine.

The hoofs are divided into four toes, not connected by membranes. The skin is nearly an inch thick, and is naked. The color of the animal when on land is of a purple brown, but when seen at the bottom of a pool it appears to be dark blue. It is thoroughly amphibious, swimming and diving like a duck, but is slow and unwieldy on land. The hippopotamus feeds on grass, young reeds, and bulbous succulent roots. It is gregarious, usually seen in troops of from five to six to as many as twenty or thirty. It is nocturnal in its habits, feeds by night, usually passing most of the day in the water. The teeth are valuable as ivory. (Andersson.)

Ruminantia.—The remaining Artiodactyles are called Ruminants, from the fact that they chew their cud. The molars are provided with two double crescent-shaped folds (Fig. 311). The stomach (Fig. 312) is divided into at least three, usually four compartments, *i.e.*, the paunch, t

FIG. 313.—Virginian Deer.

reticulum or honeycomb, so named from the polygonal cells on its interior, the *psalterium* or manyplies, and lastly the rennet or true stomach. When a sheep, cow, or any other Ruminant feeds, it thrusts out its long tongue, seizes a bunch of grass, and bites it off by pressing the incisors of the lower jaw against the toothless gum of the opposing part of the upper jaw; the mouthful of grass is then swallowed, mixed with much saliva. When its appetite is

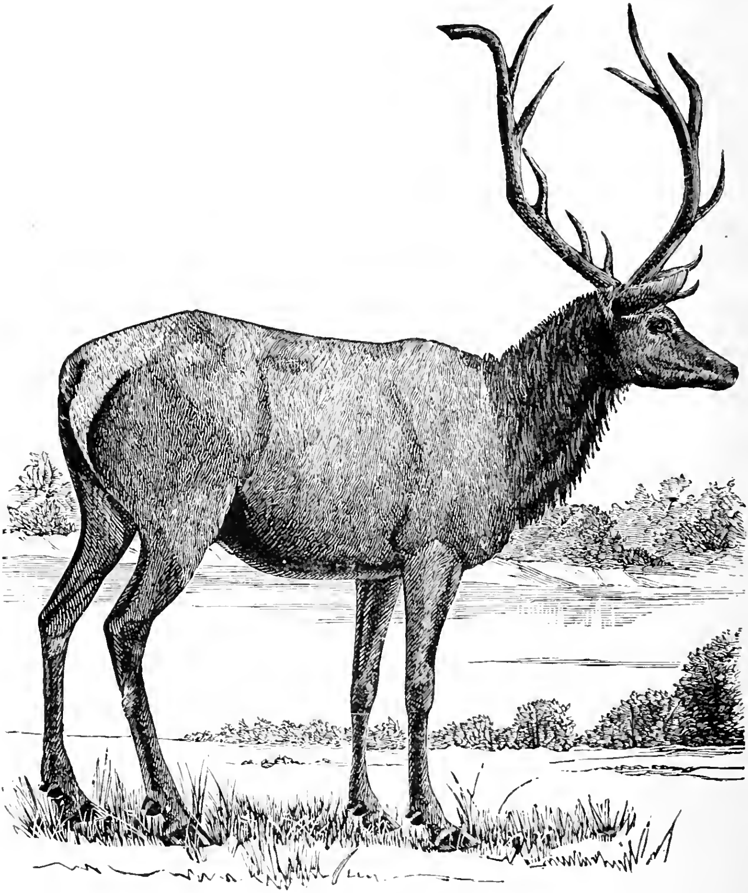

FIG. 314.—The Elk or Wapati.

satisfied it seeks a retired spot away from its carnivorous enemies, if not a domesticated animal, and after lying down, suddenly regurgitates a ball of grass, the cud,* which it

* The regurgitation of the cud is pr bably due to a sudden and simultaneous contraction of the diaphragm and of the abdominal

slowly grinds up between its molar teeth into a pulp. The cropped grass passes into the honeycomb and paunch; the manyplies serves as a strainer for the pulp, which in the fourth stomach is digested by the gastric juice.

The deer family (*Cervidæ*) is represented in the United States by the common Virginia deer (*Cariacus Virginianus*, Fig. 313), the elk or wapiti (*Cervus Canadensis*, Fig. 314), the caribou (*Rangifer caribou*), which is probably a variety of the European reindeer (*R. tarandus*), and the moose (*Alces Americanus*). The common deer ranges from the Atlantic to the Pacific and from Canada and British Columbia to Mexico; it is common about settlements and near towns. The antlers differ from those of other deer by bending more abruptly. Its summer coat is bay-red to buff-yellow: the winter coat is a varying leaden gray. The mule deer (*Cervus macrotis* Say) is so called from its large ears. It inhabits the northern Rocky Mountain region and the Pacific coast. It is awkward and ungainly compared with the common deer. The black-tailed deer (*Cervus Columbianus*) is smaller than the mule deer, and is confined to the Pacific coast of the United States and British Columbia.

The elk or wapati (Fig. 314) is next in size to the moose, the southern elk attaining the largest size: it weighs from 600 to 1000 pounds. It has been exterminated in the regions east of the Mississippi, and is now only common in the Rocky Mountain region, and to Oregon, Washington Territory, and British Columbia. The hairs of the summer coat and of the early winter coat are short and pretty solid, but as the season advances it becomes longer and crinkled, while in winter a heavy under-coat of fur is always present.* The flesh is finely flavored and unusually

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muscles, which compresses the contents of the rumen and reticulum, and drives the sodden fodder against the cardiac aperture of the stomach, which opens and the cud is propelled into the mouth. (Huxley.)

* The Antelope and Deer of America. By J. D. Caton. 1877.

nutritious. The food of the elk varies greatly: it eats grass and herbage as well as leaves and twigs of hard-wood trees.

The reindeer, or woodland caribou, inhabits the northern regions of America, Europe, and Asia. In the United States it still occurs in northern Maine, and is not uncommon in New Brunswick and Nova Scotia, abounding in Newfoundland and Labrador. The female reindeer has antlers as well as the male. The old males shed their horns usually before Christmas, but the young males carry them later, the yearlings till spring, and the females later still, until their young are born. The reindeer's foot is very broad and thin, and the accessory or hinder hoofs are of more use in supporting the body in deep snows or in marshy places than the dew-claws of any other deer. The hair is unusually long and crinkled, and underlaid by a dense coat of fur. The skin is used by the inhabitants of Labrador as well as the Esquimaux for making water-tight boots. The principal food of the reindeer is lichens, particularly the "reindeer moss."

The barren ground caribou is much smaller than the other species; it inhabits the treeless arctic border of the continent, and its habits are more arctic than any other ruminant of this continent except the musk-ox. It is more migratory than the woodland caribou, traversing in its migrations some ten degrees of latitude southward from the Arctic Ocean.

The moose (Fig. 315) is an awkward, ungainly creature, and is the largest of the family, its weight being from 700 to 1400 pounds. The antlers are large and spreading, broadly palmated, and wanting in the female, while the nose is long and flexible, and the ears enormous. It formerly ranged from the Atlantic to the Pacific coast north of latitude 43° to latitude 70°, but now it is confined to northern Maine, to Montana and Alaska, as well as to the forests of portions of British America. In summer the moose eats grass and moss, in the winter it browses on the

FIG. 315.—The Moose and other characteristic Canadian Mammals. (Porcupine, Skunk and Jumping Mouse.) After Wallace.

twigs of trees and shrubs, and it is the only one of the family which will browse on coniferous trees.

The prong-horn antelope (*Antilocapra Americana*, Fig. 316; see also Frontispiece) so characteristic of the western plains, like the true deer, drops its horns in the autumn,

FIG. 316.—Prong-horn Antelope, young.

though they are hollow when shed, and with a persistent core, as in the ox and goat. The antelope crops grass, not, like the deer, eating leaves of trees and shrubs. It is the fleetest animal on the plains, though short-winded and not capable of running a great distance.

In its horns, hollow when cast off, and in the presence of a gall-bladder, which is absent in the deer family, the prong-horn antelope connects the deer family with the *Bovidæ*, which are represented by the sheep, goat, antelope, gazelle, and ox.

The domestic sheep (*Ovis aries*) is not a natural species, but an association of races whose specific origin is obscure. Some authors regard the turf sheep of the Stone Age of Europe as the ancestor of the domestic sheep, since forms

FIG. 317.—Rocky Mountain Sheep or Big-Horn.

like it are now living in the Shetland Islands and in Wales. It was of small size, with slender legs, and erect, short horns. This sheep was supplanted by a curved, large-horned form, the modern domestic sheep. This latter

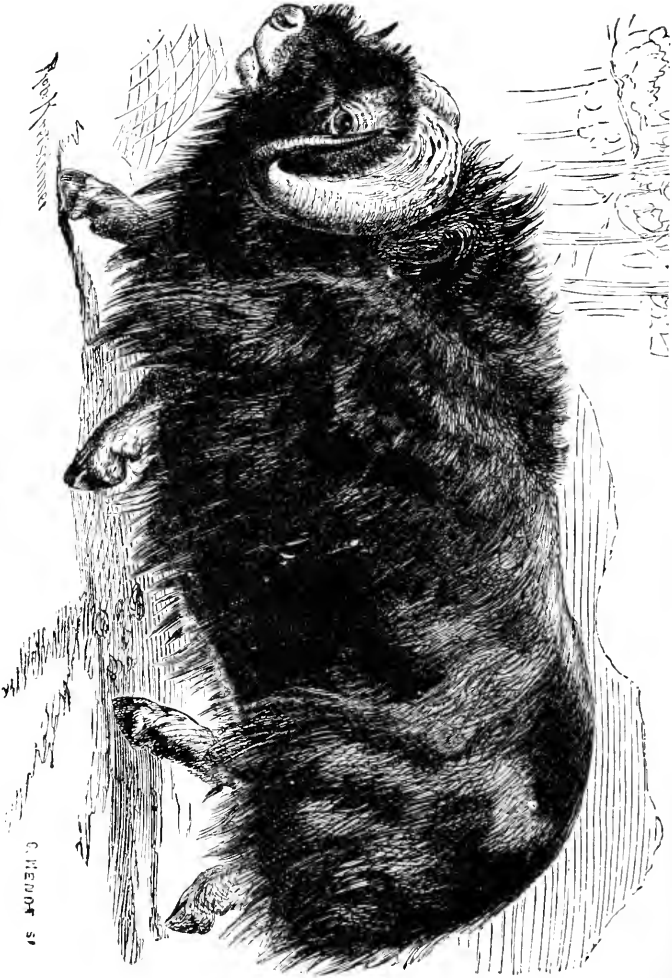

Fig. 318.—Musk Sheep.

form is possibly the descendant of the Asiatic argali (*Ovis argali*), which in North America is represented by the *Ovis Montana* or Rocky Mountain big-horn sheep (Fig. 317), still common in the less accessible summits along the upper Missouri and Yellowstone rivers, as well as the mountains of Wyoming and Montana.

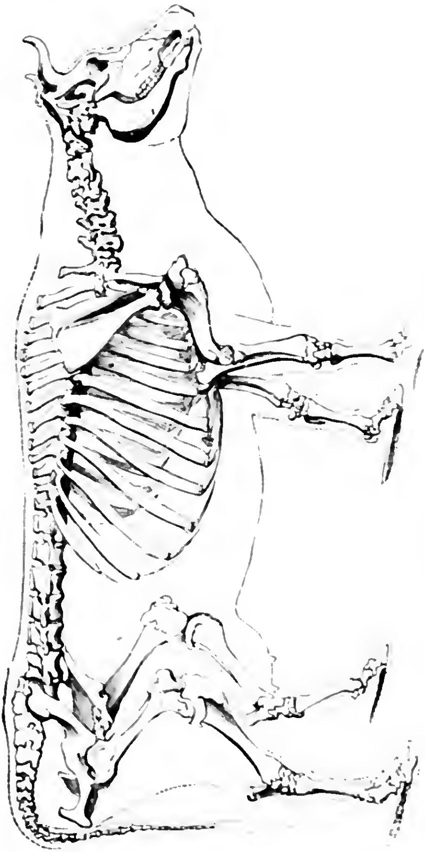

FIG. 319. Skeleton of Domestic Cow.

In the same, though higher and more inaccessible situations, lives the rare mountain goat (*Aploceros montanus*), whose horns are jet-black and polished, slender and conical. It is found sparingly in the higher summits of the

Rocky Mountains and the Cascade Range in Oregon and Washington Territory, and an individual has within a few years been shot on Mount Shasta, California.

Passing by the gazelles and true antelopes, we come to another characteristic American animal, the musk-sheep (*Ovibos moschatus*, Fig. 318), now confined to the arctic regions of America, though in post-glacial times this, or a very closely allied species, existed as far south as Ohio, and in Europe lived as far south as England, France, and Germany.

We now come to the bison and ox. The American bison (*Bison Americanus;* see Frontispiece) formerly ranged from Virginia and Lake Champlain to Florida, and westward from the northern limit of trees to the Rocky Mountains and eastern Mexico. It is now in danger of extermination, being mainly restricted to a few herds on the plains. It is closely allied to the European bison (*Bison Europæus*), the "auroch," now preserved in the forests of Bialowicza, and living wild in Caucasus. *Bos primigenius*, which in the time of Cæsar lived in Germany and England, bearing the name "urus," is the "ur" of the Niebelungen song. From it has descended the half-wild cattle in certain English parks, also certain large domestic races, such as the Holstein and Friesland breeds. From another fossil species (*Bos longifrons*) arose the so-called brown cattle of Switzerland, and the "runts" of the Scottish Highlands. Still other domestic races are traced back to another fossil quaternary species, *Bos frontosus* Nilsson. Our present races of domestic cattle, however, do not represent a genuine species, but a number of races which have descended from several fossil species; the name *Bos taurus* (Fig. 319) is simply, then, a conventional name. The bison is known to breed with cattle in the Western States, though whether the hybrids thus produced are fertile or not is unknown.

The ox is succeeded by the giraffe (Fig. 320), with its long neck, which makes it the tallest of all quadrupeds.

The last family of Ungulates, the *Camelidæ*, comprises the camels of the Old World, and the llama and vicuña of South America. In former (Tertiary) times a llama-like animal inhabited the Pacific coast to Oregon. In the camels the upper lateral incisors are present; the stomach is less distinctly divided into four chambers, the third stomach, as such, is wanting, though the second stomach has deep cells, the so-called "water-cells," which, according to Huxley, "serve to strain off from the contents of the paunch, and to retain in store, a considerable quantity of water;" thus the camel is popularly said to store up a supply of water in its stomach for its march over deserts. The toes have very large, thick pads, while the hoofs are reduced to nail-like proportions. In the camel the foot-pad is common to all the toes, but in the llama (*Auchenia*) of the eastern Andes, each toe has a distinct pad, besides the claw. The llama in a wild state keeps together in herds; from early times it has been also domesticated and

FIG. 320.—Head of Giraffe. From Lütken's Zoology.

FIG. 321.—Skull of Lion.

used as a beast of burden, and for their wool, chiefly in Peru and Chili. It is rather larger than a sheep, with the form of a camel. The Huanaco is probably the wild form of the domesticated llama (*A. lama*), while the Vicuña is perhaps the wild form of the alpaca (*Auchenia pacos*).

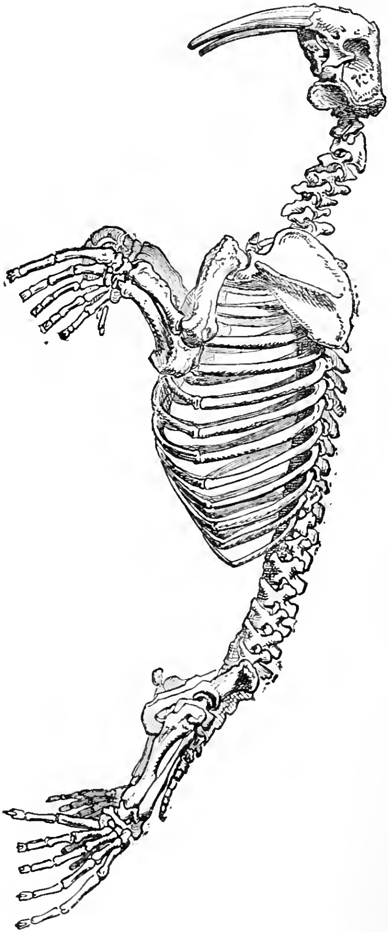

FIG. 322.—Skeleton of the Walrus.

Thus there are two wild species and two tame forms of these interesting, diminutive New-World camels.

Order 11. *Carnivora* (*Feræ*).—The bear, cat, tiger, and lion recall the leading forms of this order. The skull (Fig. 321) is massive, though the head is small or of moderate size; the teeth are all well developed, especially the canines; the molars usually have two or three roots, and the feet have large claws. The stomach is simple. The cerebral hemispheres of the lower carnivores have usually but three distinct convolutions, while the latter are much more numerous and complicated, the brain itself being broader in the aquatic forms (*Pinnipedia*). The group is divided into two sub-orders, *i.e.*, the Pinnipedia or seals,

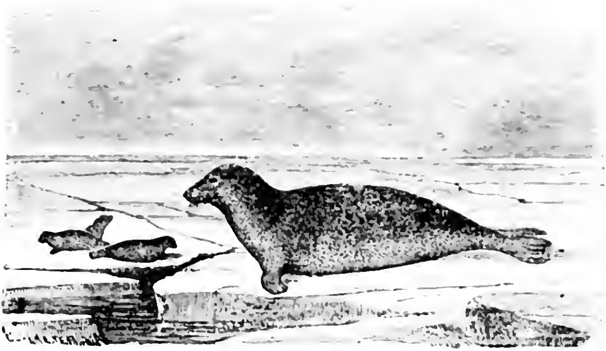

FIG. 323.—Rough Seal (*Phoca hispida*). From Nordenskiöld.

and the land species (*Fissipedia*). In the former group the feet are webbed, the toes being connected; the wrist and foot only projecting beyond the skin of the body, and there are no external ears, or only small ones.

The walrus (Fig. 322), the seals (Fig. 323), and the eared seals or sea-lions (*Otariidæ*) are the types of the aquatic Carnivores; the sea-lions can walk on all fours, and in certain peculiarities of the skull they resemble the bears.

Of the terrestrial normal *Carnivora*, the raccoon, coati, *Cercoleptes*, and bear, together with a number of extinct forms, are the more generalized or lower types. They are plantigrade, and while standing at the base of the carnivorous series, have some features suggesting and anticipating those of the lemurs and monkeys. The raccoon, *Procyon lotor* (Linn.) abounds throughout the United States. It is strictly nocturnal in its habits, and feeds on mice, young birds, birds' eggs, turtles, frogs, fish, crayfish, and shell-fish, as well as insects, nuts, and corn. It nests in hollows in trees, being a good climber. An old 'coon is a tough match for an average dog, says Merriam, and to their cunningness the saying "a sly 'coon" owes its origin. The raccoon hibernates during the severest part of the winter. Allied to it is the coati (*Nasua*) of Central America, a creature about the size of and with the general habits of the raccoon, being an exceedingly knowing and mischievous animal. A number of extinct Eocene mammals are also allied to a small plantigrade, long-tailed carnivore, *Cercoleptes*, which resembles the *Primates* in its two cutting premolars and three true molars; while the rami of the mandible are coössified; for these reasons it was placed by F. Cuvier between the orders *Carnivora* and *Primates* (Cope). It is allied to the raccoon, is called the kincajou, and lives in northern South America.

The bears have a thick, clumsy body, with a rudimentary tail, and the teeth are broad and tuberculated, so that they can live indifferently on fish, insects, or berries. Our North American species are the polar bear (*Ursus maritimus*, Fig. 324) and *Ursus arctos*, with its varieties of brown, cinnamon, and grizzly bears; and the true black bear, *Ursus Americanus*. The black bear weighs from two to four hundred pounds, and is common in the wooded or mountainous parts of the country, and is destructive to sheep, lambs, and calves. They will rarely attack man, unless wounded or in defence of their young. When the weather is severe and the snow is deep they make a den in a hollow tree, cave, or under the root of a tree, and there hibernate. They have young but once in three years. Bears can be tamed and easily taught to perform various tricks, but in growing old become unruly and often dangerous pets.

The bears are succeeded by the *Mustelidæ*, or the otter,

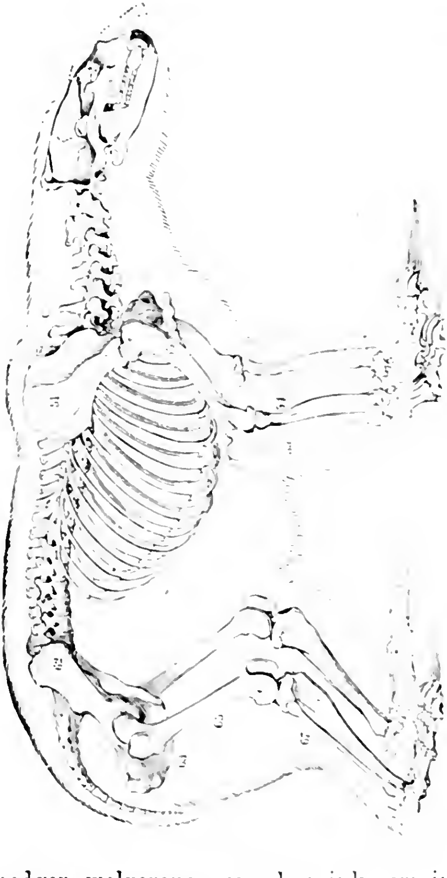

Fig. 321.—Skeleton of the Polar Bear, showing the plantigrade feet. 51, scapula; 53, humerus; 54, radius; 55, ulna; 62, ilium; 63, ischium; 65, femur; 66, tibia; 67, fibula; *cl*, calcaneum; C, cervical vertebræ. After Owen.

skunk, badger, wolverene, weasel, mink, ermine, etc., all of which are valuable for their furs.

The otter (*Lutra Canadensis*) is thoroughly amphibious It can remain under water almost as long as a loon, and

Merriam has known one to swim nearly a quarter of a mile without showing its head above the surface. It lives on fish and crayfish, as well as frogs, and is said to invade the hen-yard and even to prey upon young lambs. "It can dive and swim under water with such speed and agility, that it can overtake and secure, with great ease and certainty, almost any of our fresh-water fishes." When in winter travelling on ice they advance by "a run and a slide," *i.e.*, making several jumps and then sliding ahead flat on their bellies. The otter is also fond of "sliding down hill," both in winter on the snow, and in summer down the steep banks of stream. We have seen such "otter slides" in northern Maine, and Merriam reports them as common in the Adirondacks. The otter is one of our most valuable fur animals. Its skin becomes "prime in November, remains good throughout the winter, and is best in spring. Its nest is generally made under some shelving bank, or uprooted tree. The young are born about the middle of April, and two (rarely one or three) constitute a litter." (Merriam.)

The skunk (*Mephitis mephitica*), says Merriam, who thinks this malodorous creature has been too much abused, "is pre-eminently an insect-eater;" he destroys more beetles, grasshoppers, and the like than all our other mammals together, and in addition to these devours vast numbers of mice." Skunks hibernate only during the severest portion of the winter. They are very prolific, bringing forth six to ten young at a birth; these young, with their parents, remaining in one hole for the ensuing year.

The badger (*Taxidea Americana*) is stout and clumsy, the body very flat, with very large fore feet and claws; it digs with great rapidity, and lives so secreted a life that little is known of its habits. It lives in holes in the ground and keeps out of sight. It is now most abundant in the Upper Missouri, where its burrows are numerous. It preys on prairie-dogs and spermophiles. The badger, too slow, says Coues, to capture the nimble rodents which form its principal food, perpetually seeks them in their own retreats; and it is the work of a few minutes for this vigorous miner to so enlarge their burrows that it can enter and reach the deepest recesses. The badger, like the spermophiles, is mostly confined to the western plains.

The wolverene, glutton, or carcajou (*Gulo luscus*) inhabits the forests of northern America and the colder parts of Russia and Siberia as well as the Arctic regions. It is heavy and clumsy, with short thick legs, shaggy and two or three feet long. Its strength, ferocity, thievishness, and cunning as well as gluttonous disposition are notorious; hence its name "Indian devil." It is now very rare in the United States. It brings forth its four or five young late in June and early in July in burrows underground.

The fisher or pekan (*Mustela Pennantii*) is a large, powful animal intermediate between the wolverene and marten. Large individuals are a foot high and three and a half feet long. It frequents deep forests and wooded mountain-sides, and nests in hollow trees, and brings forth from two to four young about the first of May (Merriam). Its name fisher is misleading, as it lives away from water and seldom eats fish.

The marten or American sable (*Mustela Americana*) which is one of the most valuable of our fur animals is about the size of a large house cat, though the legs are shorter; it is about a foot and a half in length. It preys on partridges, rabbits, squirrels, mice, shrews, as well as birds' eggs and young birds. It abounds most in pine forests, and hence is often called the pine marten. It nests in hollow trees, rarely in the ground, and it has from two to eight young in April.

The weasels are much smaller than the sable, the body being slender and the fur turns white in winter. The least weasel (*Putorius vulgaris*) is said to have two or three litters in a year, having four or five young at a time. It hunts mice, moles, shrews, entering their burrows, and also devours small birds and eggs. The ermine or stoat

(*Putorius erminea*) is a little larger than the least weasel, being 8–10 inches long; it is very fierce, and attacks larger animals; it can be utilized as a ferret. The ermine, like the northern hare, arctic fox, Hudson's Bay lemming, and other animals, turns white in winter. This is usually attributed to cold weather, but Dr. Merriam thinks the change of color, which occurs suddenly, is due to snow. If it were due to temperature why should not all animals which are active in winter change color; and if to snow, why should not the mink change color as well as the ermine? Still it may in those animals which do change, have in the beginning turned white as the result of the glare of the snow on the eye and nervous system, the habit becoming inherited. Fishes and other animals change their color to white as the result of a change in the color of their surroundings. The change in such cases is due to the influence of light or darkness on the pigment or coloring matter of the skin or feathers or hair. A sudden fall of snow early in winter may cause an ermine to turn white within forty-eight hours, while for some unknown reason other animals, such as the mink, which are active through the winter, do not change; in early spring the change of color to the brown summer coat may also, as Dr. Merriam thinks, be due to the disappearance of the snow. It appears also that in Virginia and South Carolina, where there is either none or little snow, though the cold may at times be severe, that the ermine remains brown through the whole year.

The mink (*Putorius vison*), larger than the weasel, being 15–18 inches in length, is amphibious, swimming and diving after fish, while like the ermine it raids the poultry-yard. It emits a fetid and nauseating fluid from two glands situated at the base of the tail. It litters early in May in nests placed in burrows or hollow logs, and well lined with feathers, and sometimes, says Merriam, with the fur of the female. It does not turn white in winter.

The dog family (*Canidæ*) is represented by the fox, wolf, and dog. The gray fox (*Urocyon Virginianus*), the common red fox (*Vulpes vulgaris*), with its varieties, the cross, silver, and black fox, as well as the wolf (*Canis lupus*), are valuable for their furs. The common red fox is more common even in thickly settled portions of the Eastern States than is commonly supposed. Merriam thinks that it is as abundant now as a hundred years ago. "Wily, crafty, and sagacious to a degree almost beyond credibility, he defies the superior skill and intelligence of man, and meets with shrewd manœuvre and subtle stratagem all attempts at his extermination." He is active by day as well as night, and "preys upon skunks, woodchucks, musk-rats, hares, rabbits, squirrels, mice, and small birds and eggs. He is a well-known and much-dreaded depredator of the poultry-yard, destroying with equal alacrity turkeys, ducks, geese, hens, chickens, and doves; and has been known to make off with young lambs. He will also eat carrion, and even fish, and is said to be fond of ripe grapes and strawberries." Merriam, from whom we have quoted, tells us that the fox makes its nest in caverns and ledges of rocks, in burrows in the earth, and occasionally in old stumps and hollow logs. From four to nine young are brought forth at a time, the usual period being with us (Northern New York) the latter part of March or first of April.

The wolf is one of the most cowardly and yet wary, crafty, and sagacious of our wild beasts, and, when game is abundant, wantonly destructive and wasteful. It makes its lair in rocky caverns, under the roots of fallen trees, and in hollow logs. The young are born in April and May, from six to ten pups constituting a litter. (Merriam.) The wolf is mostly gray northward, becoming "southward more and more blackish and reddish, till in Florida black wolves predominate and in Texas red ones." The prairie wolf or coyoté (*Canis latrans*) is characteristic of the Western plains and Pacific coast. The Indian dogs breed with the coyoté, and the offspring is fertile. This fact appears to support the theory that the domestic dog (with its conventional name *Canis familiaris* Linn.) is a descendant of the wolf. On the other hand, fourteen kinds of dogs can be distinguished in the Roman and Greek records; of these five are principal types or species, five others climatic varieties, the remainder being either breeds artificially produced or hybrids. As regards the Egyptian dogs, seven kinds may be distinguished, three of them, besides the jackal, being distinct species. Wolves, jackals, foxes, etc., are species quite distinct from the domestic dog; they may have interbred with the latter, and have thus influenced certain breeds; but they are not the parents of the domestic dog. There are seven species among our dogs: *C. domesticus*, *extrarius* or spaniel and Newfoundland dogs, *vertagus* or

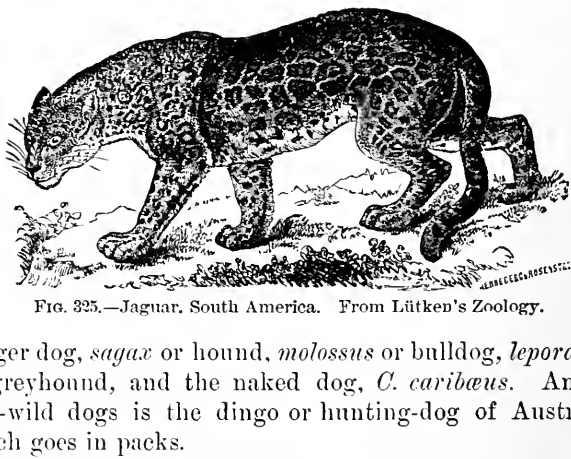

FIG. 325.—Jaguar. South America. From Lütken's Zoology.

badger dog, *sagax* or hound, *molossus* or bulldog, *leporarius* or greyhound, and the naked dog, *C. caribæus*. Among half-wild dogs is the dingo or hunting-dog of Australia, which goes in packs.

The *Viverra* and *Genetta*, or civet cats, and the hyænas, lead to the cat family, which stands at the head of the Carnivora. The jaguar (Fig. 325), panther, leopard, tiger, and lion belong to the genus *Felis*. The *Felis concolor*, cougar, panther, or puma, ranges over both continents; it is 1–1.3 metres in length. The panther destroys large numbers of porcupines, but feeds chiefly on young deer. Dr. Merriam tells us that it springs upon the deer from the ground; "on level ground a single spring of twenty feet is by no means uncommon," and it has been known to leap forty and even sixty feet from a rock twenty feet higher than the ground. The panther generally takes refuge in trees when pursued by dogs, "but under no other circumstances do any but the young sporting kittens ever climb trees." A very large panther may weigh about 200 pounds, and stand about 2½ feet high at the shoulders. It is very gaunt, but not so thin as it looks. It is not so fierce as supposed, not attacking man unless wounded and cornered. The domestic cat, *Felis domestica*, was first domesticated in Egypt, the Greeks and Romans not possessing it; the cat and common marten were in use as domesticated animals side by side; and at the same time in Italy, nine hundred years before the crusades. It appears that the domestic cat of the ancients was *Mustela foina*.

Of the lynxes there are two species in North America, *Lynx rufus*, the American wildcat, and the Canada lynx, *Lynx Canadensis* or *loup cervier*, the latter being much the larger species. The Canada lynx preys upon the northern hare and other small mammals, as well as the ruffed grouse and spruce partridge, and has been known to devour pigs, lambs, and young fawns, but does not attack, says Merriam,* full-grown deer. The female commonly has two young at a birth, her lair being usually situated in a cavern or hollow tree.

The wild cat "frequents rocky hills and ledges, and does not show that antipathy to civilization so marked in its congener, the lynx." It carries off lambs, little pigs, and poultry. Away from the farm-yard it feeds upon rabbits, squirrels, mice, grouse, and smaller birds. "It generally makes its nest in a hollow tree or log, and lines it well with moss. From two to four young constitute a litter, the most frequent number being three." (Merriam.)

Order 12. *Primates.*—The last and highest order of mammals contains a series beginning with creatures resem-

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* The Vertebrates of the Adirondack Region. 1882.

bling squirrels and bats, *i.e.*, the lemurs, and comprising monkeys, apes, and ending with man. In all the *Primates*, the legs are exserted almost or quite free from the trunk, with the great toe of the hind foot usually enlarged and opposable to the others; nails, except in the marmosets, replace claws.

The hemispheres of the brain may in the lower forms be quite smooth, but in all there is a well-developed "calcarine furrow," giving rise to a "*hippocampus minor*" within the posterior *cornu* of the ventricle, by which the posterior lobe of the cerebrum is traversed (Flower). The collar-bones (clavicles) are for the first time in the series well developed. The placenta is also different in shape from that of other mammals, being round, disk, or cake-like.

The *Primates* are divided into two sub-orders, *i.e.*, the *Prosimiæ* and *Anthropoidea*. The former group embraces the lemurs, which vary in size from that of a rabbit to a large monkey. They are covered, the face as well as the rest of the body, with a dense fur; walk on all-fours, usually have long tails, though the lori is tailless, while the fore limbs are shorter than the hind limbs. The skull is small, flattened and narrow in front; the brain-cavity small in proportion to the rest of the skull, *i.e.*, the face compared with the monkeys. The cerebral hemispheres are small and flattened, the frontal lobes narrow and pointed, and behind they only slightly cover the cerebellum.

By some authors the lemurs are separated from the *Primates*, the *Insectivora* and *Cheiroptera* being placed between the *Prosimiæ* and the other *Primates*. They have characters in which they resemble *Insectivora, Rodentia,* and *Carnivora*, but the weight of organization, or the sum of their characters, ally them nearest to the monkeys. They are therefore essentially a generalized or ancestral type. Recent discoveries have led to the hypothesis, that from still older, more generalized types four lines of development, respectively culminating in the typical Carnivores, Cetaceans, lemurs, and monkeys, have taken their origin.

That the lemurs, though now restricted to Madagascar, eastern Asia, and South Africa, were preceded by still more generalized types on the American continent, is indicated by the discovery of fossil bones in the Eocene beds of the Rocky Mountains, referred by Marsh and Cope to the Primates: Marsh stating that the principal parts of the skele-

FIG. 326.—Galago. From Lutken's Zoology.

ton are "much as in some of the lemurs." The genus *Anaptomorphus* of the Western Tertiary beds is a small lemur-like form, said by Cope to be the most like the apes of any yet discovered.

Allied to the true lemurs is a very puzzling creature, the aye-aye or *Chiromys*, of Madagascar, whose dentition differs from that of all other *Primates*, and resembles that of the Rodents; the thumb also is not truly opposable, and all the hind digits, except the great toes, have claw-like nails. The *Galago*, of West Africa (Fig. 326), somewhat recalls the *Insectivora*, while "in the more active and flexible-bodied *Lemuridæ*, the trunk-vertebræ resemble in proportions, connections, and direction of neural spines those of the agile *Carnivora*." (Owen.)

The genuine *Primates* or sub-order *Anthropoidea* are, in brief, characterized by the large, convoluted cerebral hemispheres which nearly, or in the higher apes and man, conceal the cerebrum when seen from above. The ears are rounded, with a distinct lobule, and the two mammæ are pectoral. These *Anthropoidea* are divided into two subdivisions, the first comprising the monkeys and apes, and the second, man. In the first group (*Simiæ*), the body is prone, the animal walking on all-fours, only the orang and gorilla walking partly erect; the great toe is rather short, thumb-like, and opposable to the fingers, while the body is very hairy. The monkeys of the New World have a wide septum to the nose, and are hence called *Platyrhinæ;* they also have long tails.

The little, squirrel-like, gregarious marmosets are the smallest of the monkeys and nearest allied to the lemurs. They walk on all-fours, the anterior extremities being like the hind feet, and resting on the same plane, serving as a paw; the teeth are sharply tubercled, and the nails, except those of the great toe, are claw-like. The cerebral hemispheres are nearly smooth, though relatively large. *Jacchus* and *Midas* are the typical genera, inhabiting South America. While the marmosets (*Mididæ*) have but thirty-two teeth, in the true platyrrhine monkeys there are thirty-six teeth; there being an additional molar on each side of each jaw, and the thumb is slightly opposable to the fingers (though a true thumb is wanting in the spider monkeys). The New World monkeys also have long, prehensile tails, so useful in climbing as to be sometimes called a fifth hand, as seen in the spider monkeys (*Ateles*, Fig. 327), in which the tail underneath is naked and very sensitive. The skull varies greatly in the different genera, as does the brain, which in *Chrysothrix*, etc., is nearly smooth, while in *Cebus* (Figs. 328, 329) the hemispheres are nearly as much convoluted as in the catarrhine apes. (Huxley.)

The monkeys of the Old World intergrade with the apes,

FIG. 327.—Head of *Ateles marginatus*. From Darwin.

FIG. 328.—Head of *Cebus capucinus*. From Darwin.

FIG. 329.—Head of *Cebus vellerosus*. From Darwin.

FIG. 330.—Head of *Semnopithecus cornutus*. From Darwin.

and are thus more specialized or highly developed than those of the New World. The septum of the nose is narrow, hence they are said to be *catarrhine* or thin-nosed, while the tail is short and not prehensile.

The catarrhine monkeys (*Cercopithecidæ*) walk on all-

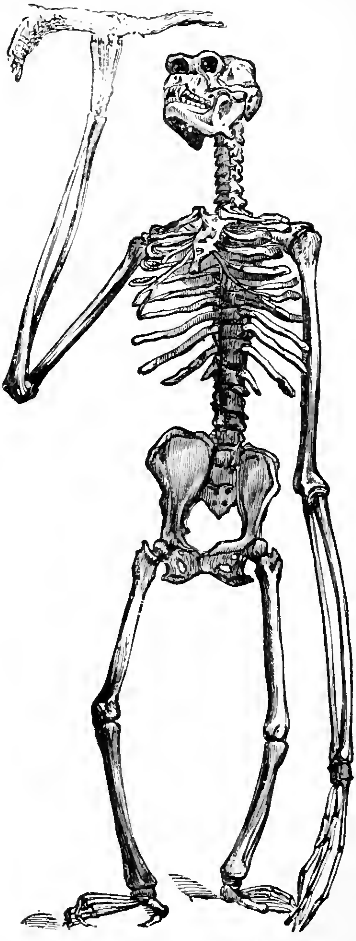

FIG. 331.—Skeleton of Siamang Ape, a gibbon.

fours, the body being horizontal or prone; they have thirty-two teeth, as in man, though the canines are large and sharp; the thumb is well-developed, and they are truly quadrumanous; the skull has a comparatively large facial angle, and the hemispheres of the brain are well furrowed. They have highly-colored, naked callosities over the ischiatic bones, and cheek-pouches for the temporary reception of the food. Of the baboons, with their dog-like muzzles and short tails, the mandrills are the most notice-

FIG. 332.—Orang-outang or Mias. From Lütken's Zoology.

able, with their white beard, scarlet lips, and blue cheeks; they are less arboreal than the macaques of Asia, running about over rocks on all-fours. The common monkeys of menageries are the macaques (*Macacus*) of India. All the foregoing catarrhine monkeys have a simple stomach, as in man, but in the sacred monkey of India (*Semnopithecus*, Fig. 330), and the African thumbless *Colobus*, the stomach is more complex.

The apes live in trees, only occasionally walking on the ground; their posture is semi-erect; they are tailless, the fore legs are much longer than the hind legs, and used as arms, the radius being capable of complete pronation and supination. In the form of their skull, of their brain

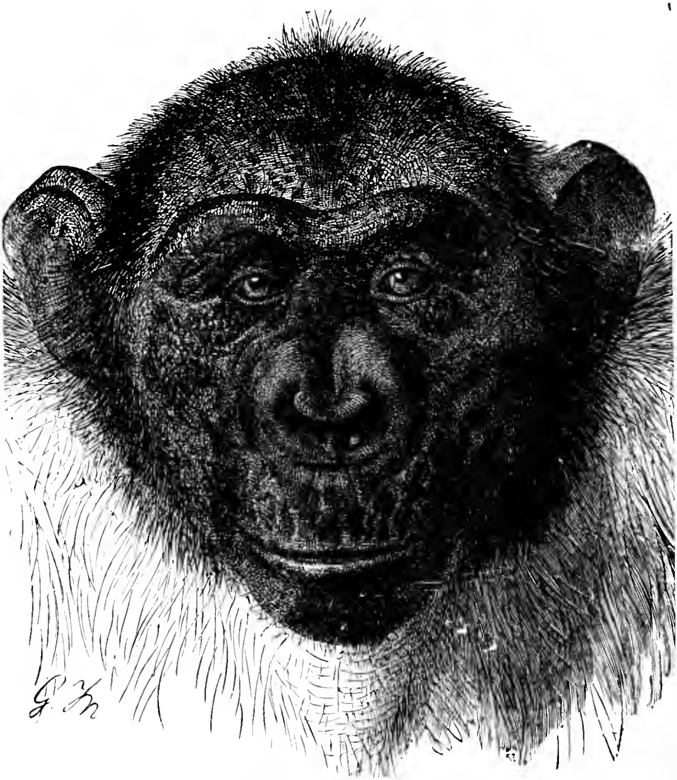

FIG. 333.—The Chimpanzee, variety Tshego. From Brehm's Thierleben.

with its convolutions, and in the teeth, there is a still nearer approach to man.

There are three typical forms or genera of apes, *i.e.*, the gibbon (*Hylobates*, Fig. 331); the orang (*Mimetes pithecus*, Fig. 332), the chimpanzee (*M. niger*, Fig. 333), and the gorilla. The gibbons are nearest to the monkeys; they are little less than a metre (3 feet) in height, and are very slender, with very long arms, so that they are rapid, agile climbers, also running over the ground with ease and rapidity; when standing erect the fingers touch the ground; only the thumbs and great toes have true nails, in all the higher apes the nails of all the digits being flattened: the spinal column is nearly straight; they have fourteen pairs of ribs and eighteen dorso-lumbar vertebræ, there being in the other apes usually seventeen, as in man. The siamang lives in the forests of Sumatra; others inhabit Java, Borneo, Cambogia, etc.

The orang-outang inhabits the low swampy forests of Sumatra and Borneo, being confined to those two islands; it is 1.38 metres* (4½–5 feet) high; it has twelve pairs of ribs, the same number as in man; the arms are very long, stretching 7 feet 9 inches, and reaching the ground, so that in walking they rest on their knuckles, swinging the body through their long arms as if walking on crutches; their posture is only partially erect. The forehead is less strongly marked than in the other apes, showing better the shape of the skull. The volume of the brain, both of the orang and chimpanzee, is about twenty-six or twenty-seven cubic inches. The following table will show, according to Wyman, the relative capacity of the skull in the different apes as compared with man:

The average	capacity	of the	Caucasian skull	is	91–92 cubic in.
"	"	"	? African	"	85 "
"	"	"	Australian	"	75–79 "
"	"	"	Gorilla	"	29 to near 35 cubic in.
"	"	"	Chimpanzee	"	26 "
"	"	"	Orang	"	25 "

* Wallace says that the orang of Borneo never exceeds 4 feet 2 inches in height. Its native name is *Mias*. ("The Malay Archipelago.")

According to Wyman, the range of variation in different races of men, as seen in seventeen skulls, is from 92 to 75 cubic inches; in the gorilla from 34 to 25 cubic inches, nine skulls having been measured.

There is but a single species of orang, which is restricted to Sumatra and Borneo. It is said to be very intelligent, to possess a voice so loud as to be heard one or two miles, and to build a nest to sleep in. It makes a fresh nest of leaves and branches nearly every night in the boughs of trees from twenty to fifty feet from the ground; with its long and powerful arms it easily climbs the tallest trees, feeding on fruits, buds, young shoots, and leaves. It does not leave its bed till the sun is well up and has dried up the dew on the leaves, and it feeds all through the middle of the day. No animal dares to attack it but the crocodile and boa; these, however, it usually vanquishes. (Wallace.)

The chimpanzee and gorilla are only found on the west coast of Africa. The chimpanzee (*Mimetes niger*, with its variety *Tschego*, Fig. 332) inhabits the coast from Sierra Leone to Congo. It is about $1\frac{1}{2}$ metres (five feet) in height. It can stand or run erect, but it usually leans forward, resting on its knuckles; the arms span about half as much again as the creature's height. Both the chimpanzee and gorilla have fourteen pairs of ribs. The chimpanzee lives on fruit, is an active climber, and nests in trees, changing its rude quarters according to circumstances. Rev. Dr. Savage states that "they generally build not far above the ground. Branches or twigs are bent, or partly broken, and crossed, and the whole supported by the body of a limb or a crotch. Sometimes a nest will be found near the *end* of a *strong leafy branch* twenty or thirty feet from the ground."

The gorilla, like the chimpanzee, goes in bands, but the company is smaller, and led by a single adult male. They make similar nests, which, however, in the case of both apes, afford no shelter, and are only occupied at night. The gorilla sometimes reaches the height of about $1\frac{1}{3}$ metres

(5½ feet) and weighs about 200 pounds. Its ordinary attitude is like that of the chimpanzee; there is a web between the first joints of all the fingers and three of the toes, and both hands and feet are broader, while the body is much more robust than in the other apes, being very broad across the shoulders. The span of the arms is to the height as three to two, or a little over eight feet. The skull is thick, and the strength and ferocity of the creature is evinced by the thick supra-orbital ridges and the high sagittal and lambdoidal crests on the top of the skull; the face is wide and long, the nose broad and flat, the lips and chin prominent. The gorilla walks like the chimpanzee, though it stoops less. It is very ferocious, bold, never running when approached or attacked by man. It lives on a range of mountains in the interior of Guinea, its habitat, so far as known, extending from a little north of the Gaboon River to the Congo.

Thus, to recapitulate, while the gibbons are most remote from man, the orangs approach him nearest in the number of the ribs, the form of the cerebral hemispheres, and other less obvious characters; the chimpanzee is nearest related to him in the form of the skull, the dentition, and the proportions of the arms, while the gorilla resembles him more in the proportions of the leg to the body, of the foot to the hand, in the size of the heel, the curvature of the spine, the form of the pelvis, and the absolute capacity of the skull (Huxley). Anatomists have differed and do differ as to whether the chimpanzee or the gorilla is nearest to man.

Whether man (*Homo sapiens* Linn.), when considered simply as an animal, is the representative of a distinct subclass, order, sub-order, or family, is not and may never be settled; though the tendency among zoologists is to leave him among the *Primates*, where he was placed by Linnæus. When we consider the slight absolute anatomical differences separating man from the apes, and take into account the great variations in form between the different genera of apes, and still more in the monkeys, it seems best, throwing out, as we have to do in a purely zoological classification, the intellectual and moral faculties of man, to adopt the view that man is the representative of a group of *Primates.** The absolute differences of man from the apes consist in the greater number and irregularity of the convolutions of the cerebral hemispheres, which are also much larger compared with the cerebellum, and completely cover the latter; the entire brain being at least double the size proportionately of that of the gorilla; † it is also stated that two muscles exist in man which have not yet been found in any ape, the *extensor primi internodii pollicis* and the *peronæus tertius,* belonging to the thumb and foot respectively (Huxley). ‡ There are also points in the origin of certain muscles which are peculiar to man, but Huxley adds that all the apparently distinctive peculiarities of the muscles of the apes are to be met with, occasionally, as varieties in man. On the other hand, the relative differences of the skulls of the gorilla and man are, as Huxley states, "immense." In man the cranial box overhangs the

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* Geoffroy St. Hilaire placed man in a kingdom by himself; Owen assigned him to a sub-class; by others he is generally regarded as a representative of an order *Bimana,* as opposed to the order Quadrumana, or monkeys and apes; while from recent comparative studies man is considered as belonging either to a separate sub-order or a family.

† "It must not be overlooked, however, that there is a very striking difference in absolute mass and weight between the lowest human brain and that of the highest ape—a difference which is all the more remarkable when we recollect that a full-grown gorilla is probably pretty nearly twice as heavy as a Bosjesman, or as many an European woman. It may be doubted whether a healthy human brain ever weighed less than thirty one or two ounces, or that the heaviest gorilla-brain has exceeded twenty ounces." In another place Huxley states that "an average European child of four years old has a brain twice as large as that of an adult gorilla."—*Man's Place in Nature.*

‡ Dr. Chapman has found in the arm of a gorilla a distinct *extensor primi internodii pollicis* muscle, but no trace of the *flexor longus pollicis.—American Naturalist,* June, 1879, p. 395.

orbits; in the gorilla the forehead is hollowed out. The hinder portion of the brain is also much more developed in man than in the apes, and in the hinder part of the hemispheres the convolutions are more numerous than in the chimpanzee, this part in monkeys losing its convolutions altogether (Wyman). Man stands erect; his arms span a distance equal to his height; the spinal column has four curves; the skin of the hands and feet of man is highly sensitive, compared with that of the apes. Finally, as Cuvier stated, the grand distinctive zoological character separating man from the other animals is the possession of the power of speech.

FIG. 334.—Skull of a Negro, showing its prognathism.

Sometimes in man the coccyx has one or two more joints than the normal number, but the apes have no tail. The black and Australian races are slightly nearer the apes than civilized peoples. In apes, as in the lower mammals, the pelvis is higher than wide; when there is a degradation in the human pelvis it tends to become higher than wide, as seen in the pelvis of the Hottentots. In civilized man the legs are one half the height of the body, but in the South Africans, Hottentots, and Bushmen the legs are a little less than half the height, and the thigh-bone is flattened from side to side, as in the gorilla. The waist is broader in the African than in the European; the *os calcis* is not longer in negroes than in the white man, the larger heel of the former being simply due to an expansion of the soft parts.

The form of the skull varies greatly in the different races, and even in individuals of the same race of mankind. This is seen in the difference of the *facial angle.* This is obtained by drawing a line from the occipital condyle along the floor of the nostrils, and intersecting it by a second, touching the most prominent parts of the forehead and upper jaw; the angle they make is an index of the cranial capacity, and of the degree of intelligence of the individual. The facial angle in the reptiles is very slight, as it is in the birds; in the dog it is 20°, in the gorilla 40°, in the Australian 85°, in the civilized Caucasian it averages 95°, while the Greek sculptors adopted an ideal angle of 100° (Owen*). When the lower part of the face protrudes, as in the negro, the face is said to be *prognathous* (Fig. 334); where the facial angle is high, and the face straight, as in the more intellectual forms, the cranium is said to be *orthognathous.* Those skulls which are high and narrow, *i.e.*, with the longer diameter to the shorter as 100 to 65, are said to be *dolichocephalic,* while those with the diameters as 100 to 85 are called *brachycephalic,* but these distinctions have been found to be quite arbitrary.

The classification of the human races is in as unsatisfactory a state as that of the domestic animals. Naturalists are now agreed that there is but one species of man. Blumenbach, from the shape of the skull and the color of the skin, divided mankind into three varieties, the white or Caucasian, the brown or Mongolian, and the black or Ethiopian, considering the American variety as connecting the Caucasian and Mongolian, and the Malayan as intermediate between the Caucasian and Ethiopian. Hamilton Smith divided man into three varieties, Caucasian, Mongolian, and Tropical; Latham, also, into three, Japetidæ,

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* Pagenstecher states that the facial angle in the Caucasian European is 80°–85°, and even over 90°; in the Mongolians 75°–80°; in negroes 70°–75°; in the tribe of Makoias in South Africa 64°; in the tribe of Tikki-Tikki, or Akka negroes, the dwarfs described by Schweinfurth, only 60°.—*Allgemeine Zoologie,* i., p. 250.

Mongolidæ, and Atlantidæ; and Pickering into white, brown, and black varieties, with intermediate races. Huxley divides the different races into two primary groups, the *Ulotrichi*, with crisp or woolly hair, and the *Leiotrichi*, with smooth hair.

The average height of Englishmen is 5.8–5.10 feet: in the universities more. In America, the average height of medical and military men is 5.9¾ feet. The Patagonian men are nearly six feet high on an average; the women 5.10 feet; the Bushmen and Esquimaux 4.7, the latter being the smallest people on the earth. The smallest dwarfs in Europe were 33 and 28 inches in height respectively; while Patrick Cotter, the Irish giant, was 8 feet 7 inches tall.

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GLOSSARY.

Ab-do'men. In mammals the part of the trunk below or behind the thorax; in insects the third region of the body, or hind body.

Ab-er'rant. Departing from the regular or normal type.

Ab-o'ral. Opposite the oral or mouth region.

A-bran'chi-ate (Gr. *a*, without; *brachia*, gills). Without branchiæ or gills.

A-cu'mi-nate. Ending in a prolonged point.

Al-ve'o-lus. A cavity forming the socket in the jaws of vertebrates for the teeth.

Am-bu-la'crum (Lat. from *ambulare*, to walk, a garden-walk). The perforated space or area in the shell of the sea-urchin or the arm of a star-fish, through which the foot-tubes or ambulacral feet are protruded.

A-me-ta'bo-lic (Gr. *a*, without; *metabole*, change). Referring to insects and other animals which do not undergo a metamorphosis.

A-mor'phous (Gr. *a*, without; *morphe*, form). Without a definite figure; shapeless; especially applicable to sponges.

Am-phi-cœ'lous (Gr. *amphi*; *koilos*, hollow). Applied to vertebræ which are doubly concave, or hollow at both ends.

A-nal'o-gy (Gr. *analogia*, proportion). The relation between organs which differ in structure, but have a similar function; as the wings of insects and birds.

A-nas-to-mo'sing. Inosculating or running into each other like veins.

An-chy-lo'sis. The growing together of two bones so as to prevent motion between them.

An-nu-late. When a leg or antenna is surrounded by narrow rings of a different color.

A'pla-cen-tal. Referring to those mammals in which the embryos are destitute of a placenta.

A-po-dous. Footless.

Ap-te-rous (Gr. *a*, without; *pteron*, wing). Destitute of wings.

A-qui'fe-rous (Lat. *aqua*, water; *fero*, I carry). Applied to the water-carrying or water-vascular system of the sponges, etc.

A-rach'ni-da (Gr. *arachne*, a spider). The class of Arthropods, embracing the spiders, scorpions, and mites.

A'RE-O-LATE. Furnished with small areas; like a network.

A-RIS'TATE. Furnished with a hair.

AR-THRO'PO-DA (Gr. *arthros*, a joint; *pous, podos*, foot). Those Articulata with jointed feet, such as crabs and insects.

AR-TI-CU-LA'TA (Lat. *articulus*, diminutive of *artus*, a joint). Cuvier's subkingdom of worms, crustacea, and insects.

AR-TI-O-DAC'TY-LA (Gr. *artios*, even; *daktulos*, finger or toe). Those Ungulates with an even number of toes, as the ox.

A-SEX'U-AL. Applied to animals, especially insects, in which the ovaries or reproductive organs are imperfectly developed; and which produce eggs or young by budding.

AU-RE'LI-A. Old term for the pupa of an insect.

AU'RI-CLE (Lat. *auricula*, a little ear). One of the cavities of the heart of mollusks and vertebrates.

AZ'Y-GOS (*α*, without; *zugon*, a yoke, a pair). An organ, such as a nerve or artery, situated in the middle line of a bilaterally symmetrical animal, which has therefore no fellow.

BÆ-NO'PO-DA (Gr. *baino*, to walk). The thoracic legs of insects.

BÆ'NO-SOME (Gr. *baino*, to walk; *soma*, body). The thorax of insects.

BI'FID. Divided into two parts; forked.

BLAS'TO-DERM (*blastos*, a bud or sprout; *derma*, skin). The first-formed layer of the germ-cells of the embryo.

BLAS'TO-PORE. The mouth of the gastrula.

BLAS'TO SPHERE. The embryo when consisting of a single cell-layer. The same as the blastula.

BLAS'TŪ-LĂ. The embryo with but a single layer of cells.

BRAN'CHI-A. A gill or respiratory organ of aquatic animals.

BUC'CAL. Relating to the mouth cavity; or rarely to the cheeks.

BUL'LATE. Blistered.

CA-DU-CI-BRAN'CHI-ATE (Lat. *caducus*, falling off; Gr. *bragchia*, gills). Applied to those *Batrachia* in which the gills become absorbed before adult life.

CAL'CA-RA-TED. Armed with spurs.

CA'LYX. A little cup; often applied to the body of a Crinoid.

CAP'I-TATE. Ending in a head or knob.

CEN-TRUM. The body or central part of a vertebra.

CE-PHAL'IC. Relating to the cephalum or head.

CE-PHAL'O-MERE. A cephalic segment of an Arthropod.

CE-PHAL'O-SOME. The head of insects, Arachnida and Myriopoda.

CER-CO'PO-DA (Gr. *cercos*, tail; *pous, podos*, foot). The last pair of jointed abdominal appendages of insects; the "cerci."

CHE'LA. The terminal portion of a limb with a movable lateral part, like the claw of a crab; as in the chelate maxilla of the scorpion.

CHI-AS'MA (Gr. *chiasma*, a crossing). The commissure of the optic nerves in most vertebrates.

CHI'TIN (Gr. *chiton*, a tunic). The horny substance in the skin of insects, etc.

CHYLE (Gr. *chulos*, juice). The milky fluid resulting from the action of the digestive fluids on the food or chyme.

CHYME (Gr. *chumos*, juice). The acid, partly fluid or partly digested food, produced by the action of the gastric juice on the food.

CIL'I-UM (pl. *cilia*). Microscopic filaments attached to cells, usually within the body, and moving usually rhythmically.

CIR'RUS. A slender process on the body of worms.

CLO'A-CA (Lat. a sewer). The common duct or passage at the end of the intestine into which the oviducts and urinary ducts open, as in reptiles, birds, and monotreme mammals.

CŒ'CAL. Ending blindly or in a cul-de-sac.

CŒ'CUM. A blind sac; usually applied to one or more appendages of the digestive canal.

CŒ-NEN'CHY-MA (Gr. *koinos*, common; *chumos*, chyme or juice). Applied in polyps to the coral mass containing the chymiferous or nutritive canals connecting the different polyps.

COL'LO-PHORE. The sucker-like organ extended from the under side of the abdomen of Podurans.

COM-MIS-SURE. The nerves connecting two ganglia.

CON-COL-O-ROUS. Of the same color as another part.

CON'DYLE (Gr. *kondulos*, a knuckle). The articular surface of a bone, especially of the occiput.

COR-TI-CAL. Relating to the cortex or inner skin; external, as opposed to medullary.

COS-TAL (Lat. *costa*, a rib). Relating to the ribs.

CRIB-RI-FORM (Lat. *cribrum*, a sieve; *forma*, form). With perforations like those of a sieve.

CROP. A partial dilatation of the gullet or œsophagus, the ingluvies; in many insects the fore stomach or proventriculus.

CU-TI-CLE. The outermost layer of the integument.

DE-CID-U-OUS. Relating to parts which fall off or are shed during life, as the gills of the frog, etc.

DEN-TATE. Furnished with teeth.

DERM-A-TOP-TE-RA (Gr. *derma*, skin; *pteron*, wing). The earwigs.

DEU-TOM-A-LE. The third pair of head appendages of Myriopoda.

DI-DEL-PHI-A (Gr. *dis*, two, or double; *delphus*, womb). The sub-class of Marsupials.

DIF-FER-EN-TI-A-TION. The specialization or setting apart of special organs for special work, as the specialization of the hand of man from the fore-foot of other mammals; also applied to the special development during embryonic life of parts adapted for peculiar or special functions.

DIG'IT. A finger or toe.

DI-MID'I-ATE. Half round.

DI-Œ'CI-OUS. (Gr. *dis*, two; *oikos*, house). With distinct sexes.

DIP'TE-RA (Gr. *dis*, two; *pteron*, wing). Two-winged flies; an order of insects.

DI-VER-TIC'U-LUM. An offshoot from a vessel or from the alimentary canal.

DUCT. A tube or passage usually leading from glands.

EC-DY'SIS (Gr. *ekdusis*, casting off). The process of casting the skin; moulting.

E-CHIN-O-DER'MA-TA (Gr. *echinos*, a hedgehog or urchin; hence applied to the sea-urchin; and *derma*, skin). The fourth subkingdom of animals.

E LAS-MO-BRAN'CHI-I (Gr. *elasma*, a strap; *bragchia*, gill). The sharks and rays.

E-LA'TER. The spring or forked "tail" of Podurans.

E-LY'TRA (Gr. *elutron*, a sheath). The fore-wings of beetles, serving to cover or sheathe the hind wings.

EM'BRY-O. The germ or young animal before leaving the egg or body of the parent.

ENDO-BLAST. The primitive, embryonic endoderm.

EN'TE-RON (Gr. *enteron*). A general term applied to the digestive canal as a whole.

E-PHEM'E-RI-NA. The order of net-veined insects represented by Ephemera.

E'-PI BLAST. The ectoderm in its embryo state. The ectoblast.

E PIB'O LE. Where the gastrula is formed by a spreading of a thin layer of epiblast cells over the much larger hypoblast cells.

E-PIS'TO-MA. That part of the face of flies situated between the front and the labrum.

E QUI-LAT'E-RAL. Having the sides equal, as in Brachiopod shells.

E'QUI-VALVE. Applied to shells like the clams and most Lamellibranchs, which are composed of two equal pieces or valves.

EX SER'TED. Protruded; opposed to enclosed.

EX-U'VI-UM. Cast-off skin.

FIS-SIP'A-ROUS (Lat. *fissus*, cleft; *pario*, to bring forth). Applied to a form of asexual generation where the parent splits into two parts, each part becoming a new individual.

FŒ'TUS. The embryo of a mammal.

GANG'LI-ON (Gr. *gagglion*, a swelling or lump). A centre of the nervous system, consisting of nerve-cells and fibres.

GEM-MIP'A-ROUS (*gemma*, bud; *pario*, to bring forth). Applied to a form of asexual generation where new individuals arise as buds from the body of the parent.

GLA'BROUS. Smooth; opposed to hairy; downy, villous.

GLAND. A cellular sac which secretes, *i.e.* separates, certain constituents of the blood. The liver is a gland secreting bile; the kidneys excrete urine.

GLAU'COUS. Bluish green or gray.

GON-OP'O-DA (Gr. *gone*, generation; *pous*, *podos*, foot). The modified first pair of abdominal appendages of the male lobster, shrimps, and crabs.

HÆ'MAL (Gr. *haima*, blood). Connected with the blood-vessels or heart.

HAL'LUX. The thumb or great toe.

HAL'TER-ES (Gr. *halteres*, poisers). Balancers: the rudimentary hind wings of Diptera.

HAUS'TEL-LATE. Furnished with a proboscis so as to take food by suction.

HE-MIP'TE-RA (Gr. *hemi*, half; *pteron*, wing). An order of insects with the fore-wings partly opaque, hence called hemelytra.

HER-MAPH'RO-DITE (Gr. *Hermes*, Mercury; *Aphrodite*, Venus). Any animal having the organs of both sexes, usually the ovary and testes, combined in the same individual.

HE-TE-RO-CER'CAL. Unevenly lobed, as in the tail of sharks and Ganoids, when the backbone is prolonged into the upper lobe.

HET-E-ROG'A-MY. = Parthenogenesis.

HEX-A'PO-DOUS. Provided with six feet.

HO-MO-CER'CAL. Even-lobed, as in the tails of bony fishes.

HO-MOL'O-GY (Gr. *homologia*, agreement). Implies identity in structure between organs which may have different uses; as the fin of a whale, and the foot of a dog, or a bird's wing. Homology implies blood-relationship, *i.e.*, a community of origin between parts which may have distinct uses.

HY'DA-TID. The bladder-worm, or the cystic stage of a tapeworm.

HY-MEN-OP'TE-RA (Gr. *humen*, hymen, or membrane; *pteron*, wing). An order of insects with two pairs of membranous wings.

HY'OID (Gr. Υ, *eidos*, resemblance). A bone in mammals, resembling the Greek letter Υ, its form being different in other vertebrates: also called *os linguæ*, from its supporting the tongue.

HY'PO-BLAST. The under or inner layer of the embryo. = ectoblast, and the endoderm of the adult.

IM-A'GO. The final or fourth, winged and adult state of insects.

IN-E-QUI-LAT-E-RAL. Having the two ends unequal, as in the clam, quohog, and most Lamellibranch shells.

IN-E'QUI-VALVE. With one valve

differing in size or shape from the other, as in the oyster or Brachiopod shells.

IR'RO-RA-TED. Freckled; sprinkled with atoms.

LAMB DOI'DAL. Referring to the lambdoidal or Λ-shaped suture, with the apex upward, in a mammal's skull.

LAM-EL-LI-BRAN'CHI A TA (Lat. *lamella*, a leaf or sheet; *branchia*, gill). A class of mollusks with large leaf-like gills.

LAR'VA (Lat. *larva*, a mask). The second stage of the insect, a caterpillar, grub, or maggot.

LUM'BAR (Lat. *lumbus*, a loin). Connected with the loins.

LU'MEN. The cavity of an organ.

MA-LI'PE-DES. The fourth and fifth pairs of head-appendages of chilopod Myriopods.

ME-DUL'LA (marrow). The spinal cord of vertebrates.

MEN'TUM (chin). The basal piece or sclerite of the labium or second maxillæ of insects. Submentum is the posterior division of the mentum.

MES-EN'TE-RON. The mid-gut or stomach.

MES'EN-TE RY (Gr. *mesos*, intermediate; *enteron*, intestine). The membrane between the intestine and abdominal walls.

ME'SO-BLAST. The primitive, embryonic mesoderm.

ME-TAG'E-NE-SIS. Alternation of generations.

ME'TA-MERE. The same as somite or arthromere.

MON-Œ'CI-OUS (Gr. *monos*, single; *oikos*, house). With the sexual glands, etc., united in the same individual.

MY'O-BLAST. The embryonic cells which become muscle cells.

MYR-I-OP'O-DA (Gr. *murios*, thousand; *pous, podos*, foot). The class of tracheates comprising the Millepedes and Centipedes.

NE-MAT'O-CYST (Gr. *nema*, a thread; *kustis*, a bladder). The nettling, stinging organs or thread-cells or lasso-cells of the jelly-fishes and polyps, etc.

NE-PHRID'I-A (Gr. *nephros*, kidney). The segmental organs of worms, etc.

NEU-ROP'TE-RA (Gr. *neuron*, nerve; *pteron*, wing). The order of net-veined insects with a complete metamorphosis.

NID-A-MEN'TAL. Referring to a nest, or egg-sac.

NO'TO CORD (Gr. *noton*, back; *chorde*, a string), or *chorda dorsalis*. The primitive support of the body of vertebrate embryos, larval ascidians, and the backbone of the lancelet and lampreys.

OB'TEC-TED. Covered; concealed.

O'DO-NA-TA (Gr. *odous*, teeth). The dragon flies.

O-DON'TO-PHORE (Gr. *odous*, a tooth; *phero*, I carry). The so-called tongue or lingual ribbon of the higher mollusks.

ŒS-OPH'A-GUS (Gr. *oisos*, a reed; *phagein*, to eat). The gullet.

ON-TOG'E-NY (Gr. *on*, *ontos*, being; *gene*, birth). The development from the egg, of an individual animal.

O-PER'CU-LUM (Lat. *operio*, to cover). In fishes one or more bones covering the gills; in Gastropod mollusks a horny plate or solid limestone mass closing the orifice of shells.

O-PIS-THO-CŒ'LOUS (Gr. *opisthen*, behind; *koilos*, hollow). Those vertebrates with bodies hollow behind and convex in front.

ORAL. Related to the mouth.

OR-NI-THO-DEL'PHI-A (Gr. *ornis*, bird; *delphus*, womb). The sub class of mammals and order *Monotremata*.

OR-THOP'TE-RA (Gr. *orthos*, straight; *pteron*, wing). The order of insects with straight narrow fore-wings, as the grasshoppers.

OS-TRA'CO-DA (Gr. *ostracodes*, shelled). A group of shelled crustacea.

O'TO-LITHS (Gr. *ous*, ear; *lithos*, stone). Small bones suspended in the internal ear of fishes, or concretions in the auditory sacs of invertebrates.

O-VIP'A-ROUS (Lat. *ovum*, an egg; *pario*, I bring forth). Applied to animals bringing forth eggs instead of living, active young.

O-VI-POS'I-TOR (Lat. *ovum*, an egg; *pono*, I place). An organ in insects homologous with the sting, by which eggs are deposited in solid substances.

O'VI-SAC. A sac or bag-like membrane attached to the parent, and containing eggs.

O-VO-VI-VIP'A-ROUS (Lat. *ovum*, an egg; *vivus*, alive; *pario*, I bring forth). Applied to such animals as retain their eggs in the body until they are hatched.

PÆ-DO-GEN'E-SIS. Parthenogenous development in larval insects.

PAL'LI-UM (Lat. a cloak). The mantle or body-wall of mollusks, which secretes the shell; adj. pallial.

PA-PIL'LA. A minute soft projection.

PA-REN'CHY-MA (Gr. *paregchuma*, from *para*, *en*, *cheo*, something poured in besides). Applied to the proper substance of viscera, excluding connective tissue, blood vessels, and other accessory parts.

PAR-THE-NO-GEN'E-SIS (Gr. *parthenos*, virgin; *genesis*, generation). Reproduction by direct growth of germs from the egg, without fertilization by male germs or spermatozoa, as in the aphis, gall insects, fluke-worm, etc.

PEL-A'GIC. Living on the high seas, away from the coast; in mid-ocean.

PER'I-SOME (Gr. *peri*, around; *soma*, body). In Crinoids the oral region of the cup or body.

PER-EN-NI-BRAN-CHI-A'TA (Lat. *perennis*, perennial; *branchia*, gill). Those Batrachia which retain their gills throughout life.

PER-IS-SO-DAC'TY-LA (Gr. *perissos*, uneven; *daktulos*, finger).

Those Ungulates with an uneven number of toes, as the horse.

PE-RI-TO-NE'UM (Gr. *peri*, around; *teino*, I stretch). The membrane lining the abdominal walls and covering the enclosed viscera.

PER-I-VIS'CE-RAL (Gr. *peri*, around; Lat. *viscera*, the internal organs, especially of the abdominal cavity). The body-cavity containing the alimentary canal with its outgrowths.

PHA-RYN'GE-AL. Relating to the pharynx.

PHY-LOG'E-NY (Gr. *phulon*, stem; *gene*, birth). The development by evolution of the members of a genus, family, order, class, or the animal kingdom as a whole.

PI'CE-OUS. Pitchy; the color of pitch; shining reddish black.

PI'LOSE. Clothed with pile, or dense short down.

PLAN'U-LA. The two-layered embryo of Cœlenterates.

PLA-TYP'TE-RA (Gr. *platus*, flat; *pteron*). The order of insects represented by the white ants, Psocidæ and Perlidæ.

PLEX'US (Lat. a knot). Applied to a knot-like mass of nerves or blood-vessels.

POL-LEX. The thumb or innermost digit of the hand or fore-foot.

POL'Y-PIDE or POL'Y-PITE. The separate animals of a Hydrozoon.

PRE'O-RAL. In front of the mouth.

PROC'ESS. A projection; used chiefly in osteology.

PRO-CŒ'LOUS (Gr. *pro*, front; *koilos*, hollow). Those vertebræ concave or hollow in front.

PROC-TO-DÆ'UM. The primitive hind gut, or rectum.

PRO-TOM'A-LÆ. The second pair of head-appendages in Myriopoda.

PRO'TO-PLASM (Gr. *protos*, first; *plasma*, from *plasso*, I mould). The albuminous, elementary matter forming cells and the body-substance of *Protozoa*.

PROX'I-MAL (Lat. *proximus*, next). The fixed end of a limb, bone, or appendage; that nearest the body; opposed to *distal*, the farther end.

PSEU-DO-PO'DI-A (Gr. *pseudes*, false; *podes*, feet). The temporary processes sent out from the bodies of *Protozoa*.

PTER-OP'O-DA (Gr. *pteron*, wing; *pous, podos*, foot). A class of pelagic mollusks.

PU-BES'CENT. Coated with very fine hairs.

PUNC'TURED. Marked with numerous small impressed dots.

PU'PA (Lat. a doll). The third or usually quiescent, chrysalis stage of insects.

PY-LO'RUS. The valve between the stomach and intestine.

RAT'I-TÆ (Lat. *ratis*, a raft). A division of birds with a keel less, raft- or punt-like sternum.

RHAB'DI-TES. The blade-like elements of the sting and ovipositor of insects.

RHI-ZO'PO-DA (Gr. *riza*, root; *pous, podos*, foot). The root footed *Protozoa*.

RO-TIF'E-RA (Lat. *rota*, a wheel; *fero*, I bear). A class of worms with a pair of ciliated vela which in motion resemble wheels.

SA-GIT'TAL. Referring to a line or plane parallel with the sagittal or median suture of the skull of higher vertebrates.

SAR'CODE (Gr. *sarx*, flesh; *odos*, way). Equivalent and earlier term for protoplasm.

SCA'BROUS. Rough like a file, with small raised dots.

SCLE'RITE. Any separate piece of an insect's integument.

SCUTE. Applied to the dorsal pieces in Myriopods.

SEP'TUM. A partition.

SO-MAT'IC. Relating to the body.

SOM'ITE. A segment of a segmented animal, such as a worm.

SE-TA'CE-OUS (Lat. *seta*, a bristle). Bristle-like.

SPI-RA-CLE (Lat. *spiro*, to breathe). The lateral breathing pores of insects.

STIG'MA-TA (Gr. *stigma*, a mark). A synonym of spiracle.

STO'LON (Lat. *stolo*, a shoot springing from the root of a plant). Applied to the root-like creeping growths of polyps and other Cœlenterates.

STO-MO-DÆ'UM. The primitive mouth and œsophagus of the embryo of worms and Arthropoda.

STREP-SIP'TE-RA (Gr. *strephis*, a twist; *pteron*, wing). A group of beetles, whose minute front wings appear as if twisted.

STRO-BI-LA (Gr. *strobilos*, a fir cone). The chain of zooids of a larval medusa; the chain of proglottides of a tape worm.

SUC-TO-RI-AL. Adapted for sucking.

SU-PRA-OR-BI-TAL. Above the orbits.

SU-TURE. A seam or impressed line between the bones of the skull or parts of the crust of an Arthropod.

SYM-PHY-SIS (Gr. *sumphusis*, a growing together). The union of two bones.

TAC-TILE. Relating to the sense of touch.

TÆ-NID-I-UM. The band or chitinous fibre, forming the so-called "spiral thread" of the tracheæ of insects.

TEL-SON (Gr. *telson*, from *telos*, end). The rudimentary terminal segment of the abdomen of Arthropods.

TEN-E-RAL. A state of the Neuropterous imago after exclusion from the pupa, in which it has not fully completed its coloring, clothing, etc.

TEN-TAC-U-LUM (Lat. *tento*, I touch). A feeler or tentacle.

TER-GUM (Lat. back). The dorsal region of Arthropods.

TEST (Lat. *testa*, a shell). The thickened integument of *Tunicata*.

TES-TA-CEOUS. Dull red; brick color.

THO-RAX (Gr. *thorax*, a breastplate). The chest in vertebrates; the middle body in insects and some crustacea.

THY-SAN-U'RA (Gr. *thusanoi*, fringes; *oura*, tail). The lowest order of insects.

TO-MEN-TOSE'. Covered with fine matted hairs.

TRA-BEC'U-LÆ (cranii), dim. of *trabs*, a beam. Applied to the longitudinal cartilaginous bars of the fore-part of the head of vertebrate embryos.

TRA'CHE-A (Gr. *tracheia*, the rough windpipe). The respiratory tube in vertebrates; the air-tube of tracheate insects.

TREM-A-TO'DA (Gr. *trema*, a pore or hole). An order of worms.

TRUN CA'TED. Cut squarely off; docked.

TU-BER'CU-LOSE. Covered with tubercles.

TUN-I-CA'TA (Lat. *tunica*, a cloak). The class of chordata called Ascidians.

UM'BO (Lat. the boss of a shield). The beak of a Lamellibranchiate shell.

UN-GU-LA'TA (Lat. *ungula*, a hoof). The order of hoofed mammals.

U-RO-DE'LA (Gr. *oura*, tail; *delos*, visible). The tailed Batrachians.

U-RO-MERE' (Gr. *ouros*, tail; *meros*, a part). Any of the abdominal segments of an Arthropod.

U-ROP'O-DA (Gr. *ouros; pous, podos*, foot). Any of the abdominal feet of Arthropoda.

U-RO-SOME' (Gr. *ouros*, tail; *meros*, a part). The abdomen of Arthropods.

U-RO STERN'ITE. The sternal or under piece of the uromeres or abdominal segments of insects.

VAC-U-OLE' (Lat. *vacuus*, empty). The little cavities in the bodies of *Protozoa*.

VEIN. Applied to the ribs or "nervures" of the wings of insects; the branches of the veins are called *venules*.

VEN'TRAL. Applied to the under side of the abdomen, or of the body of invertebrates.

VEN'TRI CLE (Lat. *ventriculus*, diminutive of *venter*). One of the cavities of the heart or brain.

VER-RIC'U-LATE. With thick set tufts of parallel hairs.

VER'RU-COSE. Covered with wart-like prominences.

VER'TE-BRA (Lat. *verto*, I turn). One of the bones of the spinal column or backbone.

VER-TI-CIL'LATE. Placed in whirls.

VES'I-CLE (Lat. *vesica*, a bladder). A little sac, bladder, or cyst.

VIS'CE-RA (Lat. *viscus*). The internal organs of the body.

VI-VIP'A-ROUS (Lat. *vivus*, alive; and *pario*, I bring forth). Applied to animals which bring forth their young alive.

ZO'ÖID (Gr. *zoön*, animal; *eidos*, form). The highly specialized organs of such animals as the Hydroids, and other compound forms which have a marked individuality, and which might be mistaken for genuine individuals.

ZO-O'PHYTE (Gr. *zoön*, animal; *phuton*, plant). Applied to the plant-like polyps, sertularians, and sponges.

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